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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Tenders addressed as noted on the Form must be delivered at the Office of the Board, not later than 2.30 p.m., on Wednesday, 24th November, 1920.

(By Order),
DUNCOMBE MANN,
Clerk to the Board. K 589

CITY OF NOTTINGHAM.

THE WORKS & WAYS COMMITTEE are prepared to receive

Tenders for the Supply of the

UNDERMENTIONED STORES and MATERIALS, the Contracts to commence on the 1st January next and to terminate on the 31st December, 1921:—

A Cement.
B Blue Lias Lime.
C Red Bricks.
D Blue Bricks.
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Patterns and Samples may be inspected at the Eastcroft Depot, London-road, Nottingham.

The Committee will not consider any Tender except on the authorised form of Tender, which must be delivered to the undersigned, in the official envelope provided, on or before Thursday, 25th November, 1920.

The lowest or any Tender will not necessarily be accepted, and Tenders will be only accepted from persons who conform to the conditions as regards paying the local standard rate of wages, &c., and to the working rules of the Nottingham district applicable to the various trades.

By order,
W. J. BOARD,
Town Clerk.

Guildhall, Nottingham.
1st November, 1920. K 565

EGYPTIAN DELTA LIGHT RAILWAYS, LTD.

(2 ft. 6 in. Gauge.)

Tenders are Invited for the

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(1) 260 STEEL BOGIE PLATFORM WAGONS with Spare Parts.

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Forms of Tender, Schedules and Specifications with General Conditions of Contract may be obtained at the Offices of the EGYPTIAN DELTA LIGHT RAILWAYS, 210 216, Gresham House, Old Broad Street, E.C. 2, on the payment of the sum of £1 1s. for each Specification, which will not be returned.

Tenders enclosed in sealed envelopes, addressed to the "Chairman and Directors" and endorsed "Tender for Wagons" or "Tender for Wheels and Axles" must be delivered at the above address not later than noon on Monday, 6th December, 1920. K 558

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Wanted for a Research

Association a TRAINED RESEARCHER, to undertake the investigation of the corrosion of non-ferrous metals and alloys, to be conducted in London. Salary £350 to £450 according to qualifications. Applications in writing, accompanied by three references to be sent to—

Mr. ALLEN B. MUNBY,
9, Old Square,
Lincoln's Inn, W.C. 2.

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THE ROYAL TECHNICAL COLLEGE, GLASGOW.

DEPARTMENT OF METALLURGY.

Applications are Invited for

the POSITION of DEMONSTRATOR AND ASSISTANT LECTURER in this Department. Salary not less than £300.

Applications should be addressed to the PROFESSOR OF METALLURGY at the College, not later than November 20th. K 526

CITY OF CARDIFF EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Principal: CHARLES COLES, B.Sc. (LOND.).

The Services are Required as

soon as possible, of an ASSISTANT LECTURER in the Engineering Department, whose duties will be concerned mainly with laboratory work.

Commencing salary £250 per annum, rising by annual increments of £20 to £450 per annum.

Applicants should have had good teaching experience, experience in the Engineering Laboratory of a Technical College, together with workshop training. He should be able to keep the equipment in good condition and to help with the design and manufacture of additional apparatus.

Applications on foolscap paper, stating age, full qualifications, teaching and other experience, and giving copies of not more than three recent testimonials, would reach the PRINCIPAL on or before Wednesday, November 17th, 1920.

JOHN J. JACKSON, B.A.,
Director of Education.

City Hall,
Cardiff. K 547

MIDDLESEX EDUCATION COMMITTEE.

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TEACHER for Day Continuation Classes in Electrical Engineering (Lectures and Laboratory Work), on Tuesdays and Wednesdays, 9.30 to 5.30. Salary in accordance with Committee's Scale for Evening Classes, i.e. £1 per session of two hours. Applications, with full statement of experience and qualifications, should be sent immediately to

B. S. GOTT,
Secretary.

Guildhall,
Westminster, S.W. 1. K 536

UNION OF SOUTH AFRICA.

BREBNER SCHOOL, BLOEMFONTEIN.

Wanted, an Assistant

MASTER for the BREBNER SCHOOL, Bloemfontein, Orange Free State, South Africa, to commence duties 19th January, 1921. Must be an Associate of the Royal College of Science, London, on the Engineering side, or a Bachelor of Science in Engineering of some recognised University, hold the Board of Education Parchment Certificate, England, or the Privy Council Certificate of Scotland, or a University Diploma in Education, or an equivalent Certificate.

He will be required to teach Mathematics and General Science in the day school and Machine Design, Construction and Drawing and the allied subjects, especially Mechanical Engineering and Mechanics, in the evening classes.

Experience in teaching essential.

Salary £360 per annum rising by annual increments of £30 per annum to £510 per annum, plus War Bonus, which at present for a married man is £123 per annum, plus about £120 per annum for evening class work.

If the successful applicant is prepared to enter into an agreement on his arrival in South Africa, to serve the Administration of the Orange Free State Province for a term of not less than three years, a refund of his passage money to Cape Town at First Class Intermediate (B 3 or B 4) or Second Class Mail (D 1) rate will be granted, on production of the usual receipts. A free railway warrant for First Class Ticket from Cape Town to Bloemfontein and a warrant for 200 lbs. excess luggage will be supplied.

Applications, in duplicate, stating age, academic and professional qualifications and length of teaching experience, with subjects taught, must reach the SECRETARY, Office of the High Commissioner for the Union of South Africa, 32, Victoria Street, London, S.W. 1, not later than 15th November, 1920. K 394

Assistant Manager Wanted

for Outside Dept., of Clyde Marine Engineering Firm.—Messrs. WM. POSTGATE & CO., Glasgow, wish to thank applicants and intimate that above VACANCY has now been FILLED. K 551

Works Manager Required

for French Works. Thorough knowledge of Railway Signalling, up-to-date works management and fluent French linguist.—Address, K 540, Offices of ENGINEERING.

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whose duties will comprise the supervision and control of Lime-stone and Dolomite Quarries, Blast Furnaces, Bessemer, Open Hearth Steel Plant, Rolling Mills, Sheet Mills, Brick-works, etc.

Applications, stating full particulars of age, experience and salary required, to be forwarded to the GENERAL MANAGER, The Ebbw Vale Steel, Iron and Coal Company, Ltd., Ebbw Vale, Mon. K 533

RANGOON PORT COMMISSIONERS.

TRAFFIC MANAGER.

The Commissioners require the

Services of a Traffic Manager.

His duties will be to regulate steamer traffic at the various wharves and jetties, the discharging and loading of cargoes, management of the inland vessels traffic, i.e., trade conducted at a specially appointed depot by river steamers plying to and from various inland ports of Burma, the management of the Port Commissioners' warehouses and their land estate.

The salary of the appointment will be rupees 1400, rising by annual increments of rupees 60 to rupees 1700, plus a house allowance of rupees 150.

Applications only to be made on a form to be obtained from Messrs. OGILVY, GILLANDERS AND CO., 67, Cornhill, London, E.C. 3, the Commissioners' Agents, not later than November 20th, 1920.

R 1999 K 537

Assistant Engineers

REQUIRED for the FEDERATED MALAY STATES GOVERNMENT RAILWAYS, for three years' service, with possible permanency.

Salary 400 dollars a month, rising annually by 25 dollars a month to 500 dollars a month. A temporary War bonus of 20 per cent. of salary is at present payable. The sterling value of the dollar is at present fixed by the Government at 2s. 4d. Free passages provided.

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GREAT INDIAN PENINSULA RAILWAY.

TWO ASSISTANT ENGINEERS.

The Directors are prepared to receive written

Applications from Duly

Qualified Candidates for TWO VACANT APPOINTMENTS in a superior grade of ASSISTANT ENGINEER on the Company's Staff in India.

Candidates, who may be between the ages of 28 and 33 years, must have received a sound general and scientific education and have served an apprenticeship to a Civil Engineer engaged in constructional work or as Engineer to a British Railway Company.

Candidates must have passed the Associate Membership Examination of the Institution of Civil Engineers or have taken a degree exempting from such Examinations; they must also have had considerable experience in the design, construction and maintenance of railways in Great Britain or in Foreign Countries.

The terms of the appointments are a three years' engagement in the first instance; this may be subsequently extended by arrangement; the salary for the first year will be Rs. 600 to Rs. 700 per mensem, according to qualifications. Increase of Rs. 50 per mensem will be given for the second year and third year. The Company will provide first-class passages to India, and the salary will commence on the date of sailing for that country.

Applicants must give a full chronological record of their education, apprenticeship, and subsequent engineering experience. Those who may have served in the late War should give particulars and dates of that service. Candidates must also state whether they are married or single.

Applications, accompanied by copies of any testimonials, must be addressed to the Company's Consulting Engineer, ROBERT WHITE, Esq., M.Inst.C.E., 3, Victoria Street, London, S.W.1. K 534

Wanted, for South Wales

Colliery, fully qualified RESIDENT ASSISTANT ELECTRICAL ENGINEER. Must be thoroughly conversant with Colliery practice and Home Office Rules regarding electricity in mines, and capable of taking full charge if required. Age not less than 28 years.—Address, stating full particulars as to age, experience, present position and salary required, in strict confidence, K 276, Offices of ENGINEERING.

Electrician, Public School

man essential, with platform personality and ability, to deliver memorised address with films and slides of Allenby's Campaign. Applicant must be able to make electrical connections for his lantern in cinema house. State experience, salary. Letters only, A.D., c/o JONES YARRELL, 19, Ryder Street, St. James's, S.W. 1. K 549

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Hydraulic Engineers, a GENTLEMAN fully conversant with Oil Mill Machinery, capable of superintending getting out of plans and estimates for same. Good salary and commission paid.—Address, stating experience and all details, K 445, Offices of ENGINEERING.

Assistant Engineer Wanted

for new Dock Works, Argentine. Experienced in setting out, giving levels and lines, etc., and preferably in ferro-concrete work. Age up to 30.—Write BOX B.R., c/o DAVIES & Co., Finch Lane, E.C. 3. K 576

Assistant Maintenance

ENGINEERS REQUIRED for the SIERRA LEONE GOVERNMENT RAILWAY, for two tours each of 12 months, service with prospect of permanency. Salary £900 a year rising by annual increments of £30 to £720 a year. Free first-class passages and single quarters provided. Liberal leave in leave in England on full salary after each tour.

Candidates, age 25-40, who have had good experience as civil engineers on railway maintenance, should apply at once, in writing, giving age and full details of experience to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/Sierra Leone 9879. Applicants must have served in some branch of H.M. Forces during the late war, unless satisfactory reasons for not having done so can be furnished. K 577

Civil Engineer Required

by the GOVERNMENT OF JAMAICA for the Railway Way and Works Department. Salary £600 a year rising by annual increments of £25 to £650 a year. Engagement for a period of three years with prospect of permanency. Free passages provided. Candidates, age 30 to 40, preferably single, who are trained Civil Engineers capable of taking charge of maintenance of permanent way, erection of buildings and stations, bridge construction, regrading, cutting out and flattening of curves, running deviations and conversant with signals and interlocking, should apply at once in writing, stating age and brief details of experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1., quoting M/Jamaica 10442. Applicants must have served in some branch of H.M. Forces during the late War, unless satisfactory reasons for not having done so can be furnished. K 535

RANGOON PORT COMMISSIONERS.

ASSISTANT ENGINEERS.

The Commissioners require the

Services of Two Assistant

CIVIL ENGINEERS with experience on Dock and Port Works and preferably with a knowledge of the design and construction of Graving Docks.

Candidates should be about 30 years of age and preference will be given to those who are corporate members of the Institution of Civil Engineers or hold some equivalent degree in Civil Engineering. The salary offered is Rs. 700 per mensem, rising by annual increments of Rs. 40 to a maximum of Rs. 900 per mensem, and the successful candidate will be allowed to count their war service (if any) after the age of 24 for increments on this scale.

The engagement in the first instance will be for three years, which may thereafter be made permanent on satisfactory service.

Free first class passage to Rangoon and £10 for expenses on the voyage will be given.

Applications only to be made on a form to be obtained, with full particulars, from Messrs. OGILVY, GILLANDERS & CO., 67, Cornhill, London, E.C. 3, the Commissioners' Agents, not later than November 16th, 1920. K 538

CITY OF BIRMINGHAM ELECTRIC SUPPLY DEPARTMENT.

ASSISTANT CONSTRUCTIONAL ENGINEER.

An Assistant Engineer is Re-

QUIRED to assist the Constructional Engineer in the preparation of specifications and plans for new buildings and lay-out of new steam and electrical plant and in superintending the erection and testing of such plant. He should have served an apprenticeship as a Mechanical Engineer and taken a full University Engineering course. Experience in the latest practice as applied to large electric generating stations will also be taken into account.

Salary will be at the rate of £370 per annum which includes, E.P.H.A. Awards.

The successful candidate will be required to undergo an approved medical examination and contribute to the Corporation Superannuation scheme.

Forms of application for the above appointment may be obtained from the undersigned, and when completed should be sent to these offices, with copies of not more than three testimonials as to experience, ability and character, addressed to Mr. R. A. CHATTOCK, City Electrical Engineer. Applications endorsed "Assistant Constructional Engineer," must be sent in not later than November 18th.

E. J. JENNINGS,
Secretary.

14, Dale End,
Birmingham. K 543

Appointments Open continued on page 4.

THE MATHEMATICAL THEORY OF A METHOD OF BOILER FEED-WATER HEATING IN STEAM TURBINE-DRIVEN POWER STATIONS.

By Robert Dowson, B.Sc. (London).

In modern steam plant design, the principal objects to be aimed at are two-fold, namely:—

1. To transfer the greatest possible amount of heat from the fuel to the water, so as to generate as much steam as possible at the chosen working pressure and superheat; in other words, the highest attainable boiler thermal efficiency is aimed at.

2. Having raised the greatest possible amount of steam for the amount of fuel burned, to get as much mechanical work as possible out of it. This implies the highest possible thermo-dynamic efficiency between the assumed steam temperature limits. These temperature limits are, of course, defined by practical considerations, and hence the initial steam temperature is made as high as practicable.

The steam pressure must also be high, as it must always be borne in mind that, although the internal energy of a gas depends only on its temperature (Joule's law), yet it is only by means of the pressure function that we are enabled to obtain work from it. In the case of steam, it would be manifestly wrong to employ a moderate steam pressure and very high initial superheat, because when the steam had expanded down to the lowest practicable condenser pressure, there would still be some superheat left in it. Hence, although the temperature of this exhaust steam was above that corresponding to the vacuum, yet we could not get any more work out of it, and we should throw an unnecessary amount of heat away.

Let us first discuss item 1. In the case of an ideal heat engine cycle (from a thermodynamic point of view), the heat is supposed to be obtained from an inexhaustible, ready-made supply at high temperature, capable of being turned on and off at will, entirely without wasteful losses. In the practical case, however, we have no such convenient supply of high-temperature heat, since we are forced to start with coal or oil at the ordinary temperature of the surroundings. The fuel and air for combustion have to be heated up to the temperature of the furnace, by the furnace itself. Now, it is very general practice in power stations to employ "feed-water economisers," in which the hot flue gases leaving the boiler or superheater are circulated round tubes through which the feed water is pumped, on its way back to the boiler. This economiser process is an attempt to recover the heat required for heating up the fresh fuel and incoming air. It is a device to improve the boiler thermal efficiency, nothing more. Looking at the matter from this point of view, the more obvious and direct way to conserve the heat referred to above is to utilise the flue gases to heat up the incoming air to the furnace; that is, to instal an air regenerator.

Let us now discuss item 2. If σ denotes the specific heat of water and L_1 the latent heat of steam, then, in a steam engine working between the temperature limits T_1 and T_2, the theoretical efficiency on the well-known Rankine-Clausius cycle is (for initially dry-saturated steam, for simplicity) given by the relation:

$$\epsilon = \frac{\sigma\left(T_1 - T_2 - T_2 \log_e \frac{T_1}{T_2}\right) + L_1\left(1 - \frac{T_2}{T_1}\right)}{\sigma(T_1 - T_2) + L_1} \quad (1)$$

In which the first expression in the numerator represents the extra work done per pound of steam, if condensation at exhaust be completely carried out, instead of being stopped at a point D in Figs. 1 and 2, such that adiabatic compression of the mixture of steam and water would restore its pressure and quality to the original state at A. That is to say, the area A D E represents:

$$\sigma\left(T_1 - T_2 - T_2 \log_e \frac{T_1}{T_2}\right) \text{ heat units (available)}$$

per pound of steam.

The first expression in the denominator represents the sensible heat which has to be supplied to the feed water by the boiler plant, in heating it up from T_2 to T_1. Now, if economisers are used to heat up, or partially heat up, the feed water, it is true that we improve the boiler thermal efficiency, but the theoretical thermodynamic efficiency of the steam cycle still remains that given in formula (1), because whether we supply the sensible heat from the boiler itself, or from the economisers, that heat has to be supplied by the boiler plant.

The question therefore arises: "If we can conserve the heat passed on in the flue gases in an air regenerator, and so maintain the boiler thermal efficiency at the value it has when ordinary economisers are used, can we then heat up the cold feed water in any way that will show a decided advantage over the older process"?

We must heat up the feed water somehow, in order to avoid injecting cold water into the hot boiler, which is very injurious from a mechanical point of view. A very crude way of doing this is to put live steam into the feed water, and the writer has reason to believe that certain firemen are guilty of this practice.

A better way of doing it, and which is largely adopted in modern power stations, is to utilise the exhaust steam from the auxiliaries to heat up the

Fig. 1.

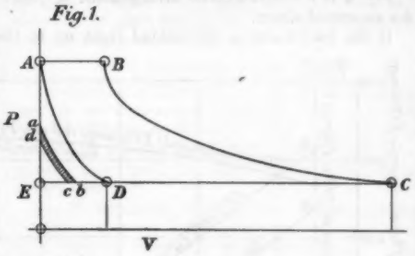
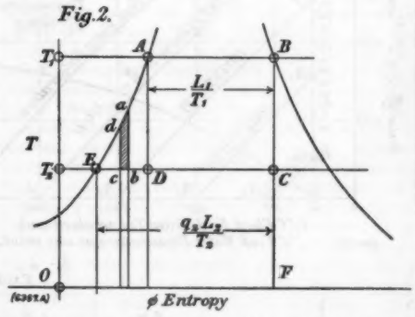


Fig. 2.



feed water. In this case, the steam used for heating purposes has at least done *some* work before being used in this manner, whereas in the former case *all* the work which the tapped-off steam could have done is lost. It is manifestly unnecessary to use steam at, say, 480 deg. F. to heat up feed water from 79 deg. F. up to 150 deg. F. The temperature difference between the steam and the water is clearly far greater than necessary.

Pushing this argument to its conclusion, it becomes evident that the more nearly the temperature of the heating steam coincides with that of the feed water it is heating up, the more work we can get out of that steam before it is used for heating purposes. This naturally suggests tapping off steam from a turbine engine itself at several points, all at a different temperature, and thus heating up the feedwater by stages. In the limit, when the number of such feed heaters becomes indefinitely great, then the temperature difference between the steam tapped off and the water it heats up, becomes indefinitely small, and we have a truly "reversible" thermodynamic process. That is to say, any slight external application of heat to the feed water in any heater would cause the condensed heating steam to re-evaporate.

Let us now turn again to the diagrams in Figs. 1 and 2. We stated before that the area A D E represents a certain definite portion of the total work done per pound of steam in expanding to vacuum temperature and then being completely condensed, and that this amount of work is numerically-equal to:

$$\sigma\left(T_1 - T_2 - T_2 \log_e \frac{T_1}{T_2}\right) \text{ heat units.}$$

Now, it will be recalled that this expression is arrived at by dividing up the area A D E into little strips $a\,b\,c\,d$, bounded by adiabatic lines $a\,b$ and $c\,d$. We are then said to divide up the area A D E into a number of indefinitely small "reversible" cycles, and we remember that no heat engine can be more efficient than a thermodynamically "reversible" one. The efficiency of these little cycles in the limiting case, where there is an indefinitely large number of them, is therefore theoretically the ideal between the temperature limits of each, and we have the total work done in the area A D E

$$= \int_{T_2}^{T_1} \sigma\left(\frac{T - T_2}{T}\right) dT = \sigma\left(T_1 - T_2 - T_2 \log_e \frac{T_1}{T_2}\right) \quad (2)$$

as above, on the assumption that σ, the specific heat of water, may be taken as unity.

We now see how the method of tapping off steam at a large number of points along a steam turbine, in order to heat up the feed water, fits in with the above requirements.

By tapping off steam at an indefinitely large number of points, the feed-water heating process becomes truly reversible, whilst the sensible heat, namely:

$$\sigma(T_1 - T_2),$$

we can now legitimately say has not to be supplied by the boiler plant at all, because what becomes of the steam after it leaves the boiler plant is no concern of the latter's.

In our expression (1) for the Rankine efficiency, therefore, the term

$$\sigma(T_1 - T_2)$$

vanishes, but we also see that by tapping off steam, we rob the turbine of some of its output, so that the numerator of formula (1) will also be diminished.

It is the purpose of this paper to show that, in the limiting case, with an indefinitely large number of feed heaters, operating in the manner described, the total work lost by tapping off the steam is numerically equal to

$$\sigma\left(T_1 - T_2 - T_2 \log_e \frac{T_1}{T_2}\right),$$

per pound of steam entering the turbine, so that the theoretical efficiency is altered from the form it takes in formula (1), and becomes

$$\epsilon = \frac{L_1\left(1 - \frac{T_2}{T_1}\right)}{L_1} = \left(1 - \frac{T_2}{T_1}\right); \quad . \quad . \quad (3)$$

which is the ideal between the assumed steam temperature limits T_1 and T_2 and is very much greater than that given by formula (1) for the same temperature limits.

In other words, a very great saving in fuel may be effected, even by only partially heating up the feed water by this method, especially if the thermal efficiency of the boiler can be maintained at its former value.

The practical case of initial superheat, and two or three heaters only, is also discussed in this paper.

Section (2). Theory.

We shall commence, then, by considering the simplest mathematical case possible, namely, that of a turbine supplied with initially dry-saturated steam, the feed water being heated right up to boiler temperature by an infinite number of stages, the steam tapped off from the turbine at each stage being sensibly at the same temperature as the feed water at each successive point during the process of heating up.

We shall also assume that the condensed heating steam mixes with the feed water, and becomes a part of it. The total amount of feed water to be heated up is therefore an increasing quantity as the temperature rises.

Let

- Q = the total steam consumption of the turbine (lb/hour).
- w = the total pounds of steam/hour tapped off up to any point, reckoning from the steam end of the turbine.
- dw = the pounds of steam/hour tapped off at any point.
- L = the latent heat of the steam at that point, and q the quality.
- dT = the temperature rise produced in the feed water at any point.

Then we have:

$$\sigma(Q - w)\,dT = -qL\,dw. \quad . \quad (4)$$

the negative sign being placed on the right-hand side, because the total amount of steam tapped off up to any point is measured from the opposite end to the rise in temperature of the feed water. We now make a reasonable assumption, which can be justified, in order to simplify the mathematics, namely that $q\,L$ = a constant throughout the expansion in the turbine. With isentropic expansion, this is equivalent to assuming that the water line E A in the temperature-entropy diagram in Fig. 2 is a rectangular hyperbola, whose Cartesian axes are F B and F O. To justify this assumption for a turbine with true isentropic expansion, we will take three examples from Callander's steam chart. In actual practice, of course, the expansion line is not truly isentropic, but in a turbine of large output, the efficiency ratio will reach over 80 per cent. (internally), and a glance at Tables I, II and III will show that the deviation of $q\,L$ from its initial value is likely to be corrected by this circumstance.

Isentropic Expansion of Dry-saturated Steam.

TABLE I.

P abs.	T deg. C.	q.	L.	$q\,L$.
500	243	1·00	428	428
200	194	0·9276	472	437
100	164	0·888	496	440
50	138	0·8646	516	446
20	109	0·8188	535	437
10	90	0·796	545	434
5	72·3	0·7747	555	430
2	52·2	0·749	567	424
1	38·8	0·731	574	420
0·5	26·4	0·717	580	415
			Mean ..	431

TABLE II.

P abs.	T deg. C.	q.	L.	$q\,L$.
—				
200	194	1·00	472	472
100	164	0·964	496	474
50	138	0·9137	516	472
20	109	0·8735	535	468
10	90	0·8464	545	461
5	72·3	0·8214	555	456
2	52·2	0·792	567	449
1	38·8	0·7738	574	445
0·5	26·4	0·7548	580	438
			Mean ..	459

TABLE III.

P abs.	T deg. C.	q.	L.	$q\,L$.
—				
—				
100	164	1·00	496	496
50	138	0·956	516	492
20	109	0·9104	535	489
10	90	0·8807	545	480
5	72·3	0·8545	555	474
2	52·2	0·8233	567	466
1	38·8	0·801	574	461
0·5	26·4	0·782	580	454
			Mean ..	476·5

Hence we may write:

$$\lambda = -\frac{\sigma}{q\,L} = \text{a constant},$$

and we have for the differential equation representing the quantity of steam to be tapped off at any point where the temperature is T:

$$\frac{d\,w}{d\,T} + \lambda\,w = \lambda\,Q. \quad . \quad . \quad (5)$$

This equation shows that $\frac{d\,w}{d\,t}$ depends on w itself at any instant, and consequently the relation between w and T must be an exponential one.

Inserting the integrating factor:

$$e^{\int \lambda\,d\,T} = e^{\lambda\,T};$$

we have:

$$\frac{d}{d\,T}\left(w\,.\,e^{\lambda\,T}\right) = \lambda\,Q\,e^{\lambda\,T}$$

or

$$w\,.\,e^{\lambda\,T} = Q\,.\,e^{\lambda\,T} + A \quad . \quad . \quad . \quad (6)$$

Now when

$$w = 0,$$
$$T = T_1$$

Hence

$$0 = Q\,.\,e^{\lambda\,T_1} + A$$
$$\therefore A = -\,Q\,.\,e^{\lambda\,T_1}$$

Thus

$$w\,e^{\lambda\,T} = Q\,.\,e^{\lambda\,T} - Q\,.\,e^{\lambda\,T_1}$$

or

$$\frac{w}{Q} = 1 - e^{\lambda\,(T_1 - T)}. \quad . \quad . \quad . \quad (7)$$

This is the general equation for the curve of total discharge of heating steam (measured from the steam end) down to a point where the resulting temperature of the feed water is T, the final feed-water temperature being T_1. Now when

$$T = T_2$$
$$w = W$$

hence

$$\frac{W}{Q} = 1 - e^{\lambda\,(T_1 - T_2)} = 1 - e^{-\frac{\sigma}{q\,L}(T_1 - T_2)} \quad . \quad . \quad (8)$$

This equation gives us the total quantity of steam to be tapped off, in order to heat up the feed water from T_1 to T_2. The difference only of the temperatures being concerned in equation (2), we may substitute $(t_1 - t_2)$ for the absolute values.

Fig. 4 is a diagrammatic arrangement of plant; for saturated steam.

If the feed water is not heated right up to the initial (boiler) temperature, then t_1, the final feed-water temperature, is reckoned at the first point of tap-off, counting from the steam end.

From equation (7) we can plot curves of steam discharge for any given conditions, and obtain a group of curves in each case, as shown in Fig. 3. As we should expect, the curves show that $\left(\frac{d\,w}{d\,T}\right)$ diminishes as we approach the exhaust end of the turbine, since Q at the exhaust is less than the total consumption of the turbine, by the total amount of steam tapped off.

Example 1.—Let the initial steam temperature be 250 deg. C. (482 deg. F.) so that the saturation pressure is 565·6 lb./in.² absolute.

Let t be the feed-water temperature at any point during the process of heating up, whilst $t = 26{\cdot}4$ deg. C. (79·5 deg. F.) at exhaust

Then we have

$$w\,.\,e^{\lambda\,T} = Q\,.\,e^{\lambda\,T} - Q\,.\,e^{\lambda\,T_1}$$

or

$$\frac{w}{Q} = 1 - e^{\lambda\,(t_1 - t)} \quad . \quad . \quad (9)$$

Now

$$= -\frac{\sigma}{q\,L} = -\frac{1{\cdot}00}{421} = -\,0{\cdot}00237;$$

421 calories Centigrade being the initial value of $q\,L$.

We thus obtain Table IV subjoined.

Having thus shown how to calculate a curve of the approximate quantities of steam to be tapped off for any assumed final feed-water temperature, we have now to find an expression for the loss of power entailed, *i.e.*, the work that could be done by the steam that has been tapped off, if it were allowed to continue its expansion in the turbine.

Now $d\,w$ = the pounds of steam/hour tapped off at any point where the temperature is T deg. absolute, the feed water being thereby heated up from T − dT to T. Hence the work which the steam could have done is:

$$d\,\Omega = d\,w\left\{\sigma\left(T - T_2 - T_2 \log_e \frac{T}{T_2}\right) + q\,L\left(1 - \frac{T_2}{T}\right)\right.$$

also we have from (4)

$$d\,w = -\frac{\sigma}{q\,L}(Q - w)\,d\,T = \lambda\,(Q - w)\,d\,T$$

and from (7)

$$w = Q\left(1 - e^{\lambda\,(T_1 - T)}\right)$$

We thus obtain by substitution:

$$d\,\Omega = \lambda\,(Q - w)\left\{\sigma\left(T - T_2 - T_2 \log_e \frac{T}{T_2}\right) + q\,L\left(1 - \frac{T_2}{T}\right)\right\} d\,T$$

or

$$d\,\Omega = \lambda\,Q\,e^{\lambda\,(T_1 - T)}\left\{\sigma\left(T - T_2 - T_2 \log_e \frac{T}{T_2}\right) + q\,L\left(1 - \frac{T_2}{T}\right)\right\} d\,T \quad . \quad . \quad (10)$$

Hence the total work that could have been done by the tapped-off steam is:

$$\Omega = \sigma\,\lambda\,Q \int_{T_1}^{T_2} e^{\lambda\,(T_1 - T)}\left\{T - T_2 - T_2 \log_e \frac{T}{T_2} - \frac{1}{\lambda}\left(1 - \frac{T_2}{T}\right)\right\} d\,T \quad . \quad . \quad . \quad (11)$$

The integration of this expression by parts is a simple matter, and we obtain:

$$\Omega = \sigma\,\lambda\,Q\left[\left(T + \frac{1}{\lambda}\right) - \frac{1}{\lambda}e^{\lambda\,(T_1 - T)}\,.\left(T + \frac{1}{\lambda}\right) + \frac{T_2}{\lambda}\,.\,e^{\lambda\,(T_1 - T)} + \left(T_2 \log_e \frac{T}{T_2} + \frac{1}{\lambda}\right) e^{\lambda\,(T_1 - T)}\right]_{T_1}^{T_2}$$
$$= \sigma\,Q\left[T_2 - e^{\lambda\,(T_1 - T)}\left\{-T + T_2 + T_2 \log_e \frac{T}{T_2}\right\}\right]_{T_1}^{T_2} \quad (12)$$

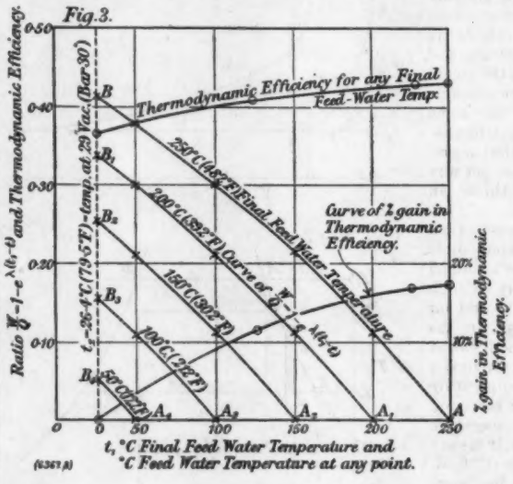


Fig.3.
Thermodynamic Efficiency for any Final Feed-Water Temp.
250°C (482°F) Final Feed-Water Temp.
200°C (392°F) Final Feed-Water Temperature
150°C (302°F)
100°C (212°F)
50°C (122°F)
Curve of Σ gain in Thermodynamic Efficiency.
Ratio W/Q = 1 − e^{λ(t₁−t)} and Thermodynamic Efficiency
Σ gain in Thermodynamic Efficiency.
t₂ = 26·4°C (79·5°F) = temp. at 29 Vac. (Bar 30)
t₁ °C Final Feed Water Temperature and t °C Feed Water Temperature at any point.
(8367.B)

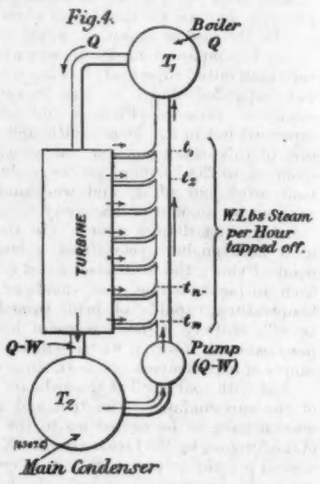


TABLE IV.

t_1	t	$R = (t_1 - t)$	$\lambda\,R = \log_e y$	$\log_{10} y$	$y = e^{\lambda\,R}$	$1 - e^{\lambda\,R} = w/Q$
Deg. C.	Deg. C.					
250	26·4	223·6	− 0·530	− 0·23 = $\bar{1}$·77	0·5888	0·4112
250	50·0	200·0	− 0·474	− 0·2055 = $\bar{1}$·7945	0·623	0·377
250	100·0	150·0	− 0·356	− 0·1545 = $\bar{1}$·8455	0·700	0·300
250	150·0	100·0	− 0·237	− 0·103 = $\bar{1}$·897	0·788	0·212
250	200·0	50·0	− 0·1185	− 0·1534 = $\bar{1}$·9486	0·888	0·112
250	250·0	0·0	0·00	0·00 0·00	1·00	0·00

and putting in the limits, we have:

$$\Omega = \sigma Q \left[e^{\lambda (T_1 - T_2)} \left\{ - T_2 + T_2 + T_2 \log_e \frac{T_2}{T_2} \right\} - e^{\lambda (T_1 - T_1)} \left\{ - T_1 + T_2 + T_2 \log_e \frac{T_1}{T_2} \right\} \right]$$

$$= \sigma Q \left(T_1 - T_2 - T_2 \log_e \frac{T_1}{T_2} \right) \quad . \quad (13)$$

Turning back to equation (1), we see that the expression (13) is identical with the first part of the numerator, when Q is taken as unity.

Hence we see that the resulting theoretical efficiency with complete feed-water heating by the tap-off method becomes:

$$\epsilon = \frac{Q \cdot L \left(1 - \frac{T_2}{T_1} \right)}{Q \cdot L} = 1 - \frac{T_2}{T_1} \quad . \quad (14)$$

which is the same as that of the ideal cycle A B C D, in Figs. 1 and 2. Thus, by simplifying the mathematics by making the assumption that q L remains constant throughout the expansion in the turbine, we have arrived at the result that the work lost by tapping off steam to raise the feed-water temperature up to boiler temperature, is independent of L, the latent heat, and is numerically equal to that done by the main turbines in the area A D E, Figs. 1 and 2, if the whole of the steam goes to the condenser, and is completely condensed.

(To be continued.)

COLLOIDS.

(Concluded from page 582.)

We were compelled last week to leave over for future consideration a good many papers of considerable technical interest which contributed to the general discussion on "The Physics and Chemistry of Colloids and their Bearing on Industrial Questions," held by the Faraday Society and the Physical Society of London, at their joint meeting held on October 26. With some of these we now propose to deal.

Glass and Pyrosols.

Sir Herbert Jackson, F.R.S., expressed doubts, when introducing the problems of "Glass and Pyrosols," as to the relevancy of the subject in a discussion on colloids. If he somewhat sidetracked the theoretical problems, however, the shunting was of technical importance. Studying, at King's College and at the National Physical Laboratory, the question whether or not glass had a structure, they had found that some glasses phosphoresced. That suggested a crystalline structure, but a glass need not be non-crystalline, because it would not phosphoresce. Almost every glass could be made crystalline by rapid chilling. At the beginning of the war they had had much trouble with crystallising glasses, largely owing to the presence of water. A glass made with anhydrous borax might be annealed for five months, but a few per cent. of moisture in the batch would spoil annealing for five minutes. The distribution of the silicates in the interior and surface of the glass had little to do with the structure, and the figures brought out by etching and glue coatings were very difficult to interpret. His pyrosols were certainly not colloidal, but one could not exclude opals. A cooled borax bead was first vitreous; it turned opalescent, and finally a crystal was seen inside. The coarse particles inside became smaller outside and amorphous (structureless) on the surface. Two types of coloured glasses might be distinguished:—(1) Those containing oxides of Fe, Ni, Co, Cr, could not be obtained colourless by rapid chilling; (2) those containing An, Ag, Cu (deoxidised), S, Se (also the platinum metals) could be obtained quite colourless by chilling. Where was the gold in the colourless condition? The particles might be too small, but he believed there was combination. Tin oxide fused in a borax bead was red or white; by adding more borax or soda one could play with the colour. The varying colours of Ni, and Co glasses also spoke for coloured compounds. Copper sulphate remained blue until it lost the last of its six molecules of water of crystallisation. When a rod of gold glass was cut through, and different layers were examined in a very powerful beam of light (in which even quartz scattered light), the surface layer appeared dark red, almost black. Inside the glass was bronze yellow and then jay-green. Similarly individual coloured particles, mostly green, and bronze in colour, could be distinguished in the ground-up glass. But green copper glass contained no green particles. In silver glass blue and white particles were discernible, in the platinum glasses only grey particles. The colour was not only due to subdivision, therefore; there was an individual influence of the metal.

Dr. M. W. Travers, F.R.S., said that glass was described as a plastic, solid or liquid, but had not been properly studied over large temperature ranges. Recent experiments made at the Bureau of Standards by heating glasses up to within 70 deg. C. of its melting point at rates of 1 deg. per two minutes, showed that the various glasses expanded regularly up to about 400 deg. C., expanding four times more rapidly afterwards before softening. The rate of heat absorption also changed, and the phenomena were hence not continuous. Dr. Travers also referred to Quincke's suggestion of a foam bubble structure of glass and to novel experiments by Mr. A. E. Griffiths supporting such a view.

Nitrocellulose.

The reading of three papers on nitrocellulose gave rise to an instructive prolonged discussion. Sir Robert Robertson, K.B.E., F.R.S., introduced the subject by a paper bearing this title, which we reprinted (abridged) on pages 572 to 574 of last week's issue.

Mr. F. Sproxton, B.Sc., F.I.C., of Manningtree, in his paper on "Non-Aqueous Colloid Systems with Special Reference to Nitrocellulose," dealt with the theoretical considerations arising from researches such as Sir Robert Robertson had described. Frank Baker had ascribed the solubility of nitrocellulose to the formation of an ether-alcohol complex. According to Gibson and McCall the optimum solvent for a nitrocellulose depended upon the nitrogen contents, but that was qualitatively also in agreement with Baker's view. The solvent power could be studied, Mr. Sproxton pointed out, (1) by viscosity determinations assuming that the best solvent would yield solutions of lowest viscosity; (2) by determining the transition temperature at which the liquid became solvent; (3) by determining the amount of diluent permissible before precipitation would occur; (4) by determining the amount dissolved from a sample of cellulose ester of incomplete solubility. These four methods might not all lead to the same result, but they were not contradictory. Passing to solid celluloid, Mr. Sproxton expressed the belief that its manufacture from nitrocellulose and camphor was really a gradual transformation from a gel to a solid, accompanied by a loss of solvents, alcohol and camphor. During the seasoning this loss was rapid at first, and the hard skin formed always retained traces of alcohol. The plasticity of the warm celluloid had led to interesting speculations. Nitrocellulose had no melting-point, camphor melted at 182·5 deg. C., and celluloid became appreciably plastic at 80 deg. C.; any alcohol retained favoured this partial melting, but camphor alone formed liquid mixtures with several solids. Speaking as a celluloid manufacturer and referring, in particular, also to Sir Robert's statement on the coherence of nitrocellulose (*vide* the first column of page 573 in our reproduction), Mr. Sproxton was doubtful about the value of Sir R. Robertson's breaking and tensile tests of nitrocellulose, although nitrocellulose and celluloid were not parallel cases. They tested their celluloid sheets simply by bringing them flat down on the table; celluloid tubes, boiled for a long time, broke into pieces resembling porcelain.

The investigation of the third paper by Dr. Guy Barr and Mr. L. L. Bircumshaw, of the National Physical Laboratory, on the "Viscosity of Some Cellulose Acetate solutions" was conducted for the Advisory Committee on Aeronautics and concerns the manufacture of non-inflammable dopes for tautening the fabric on the wings of aeroplanes. In this process the viscosity of the solution of the cellulose acetate not only limits the concentration convenient for use, but also necessitates the use of less than the maximum viscosity in acetone solution, which should be more "degraded" and have smaller film strength than the best acetate that can be manufactured. The point investigated, that small quantities of water have a considerable influence on the solubility of cellulose acetate and acetone and also on the viscosity of the solutions, had been known; but quantitative data were lacking, and Messrs. Barr and Bircumshaw therefore studied the curve: viscosity-water concentration, for a 5 per cent. solution of the acetate in pure acetone, and similarly the influence of benzene and of ethyl alcohol on acetone solutions of cellulose acetate, in each case carrying the dilution (with water, etc.) up to the point at which the acetate was precipitated. The densities of the respective solutions were tested in a small bulb pycrimeter, the viscosities in an Ostwald viscosimeter. The three types of curves obtained were very different. The density increased in all the three cases; the viscosity decreased decidedly on addition of water, to a minimum at about 20 molecular per cent. of water, and then increased again, first slowly, then rapidly. The addition of benzine produced a less strong increase in the density and a continuous and very strong increase in the viscosity. The addition of ethyl alcohol produced still smaller increase in density; the viscosity first decreased until about 6 molecular per cent. of alcohol had been added, and kept then fairly constant.

Commenting upon these papers Mr. Highfield, of Woolwich, proved by figures that the assumed ether-alcohol complex could not be decisive for the viscosity of the nitrocellulose; water decidedly played an important part, and the very difficult subject was much better explicable by the suggestion of a ternary system, ether-alcohol-water. Dr. Masson further pointed out that there was undoubtedly interaction between the alcohol and ether which affected the adsorption and solubility of the nitrocellulose; viscosity determinations were rathe unreliable unless performed under very special conditions. Sir Robert Robertson quite agreed to these arguments; the subject, he considered, needed much further investigation.

Rubber.

The next subject, "Rubber," was introduced by Mr. B. D. Porritt, M.Sc., F.I.C., who reviewed in a paper on "The Action of Light and of Oxygen on Rubber" the history of the subject and described recent experiments of his own made in the laboratories of the North British Rubber Company. The rays that deteriorated rubber, he pointed out, were the actinic rays; they could be stopped by lead pigments or salts of other heavy metals or by dyeing the outside ply of cotton yellow. His viscosimeter studies showed the need of an instrument really suitable for the tests. One might in general say that light and oxygen acted in two stages. The first stage produced "tackiness"; oxygen served as a catalyst together with other (positive or negative) catalysts; during the second "perishing" stage a peroxide acting as autocatalyst seemed to be formed. Both the actions led first to a reduction in viscosity which could be reproduced by the application of heat or of mechanical work, though the changes were not quite analogous. In the presence of sulphur, rays from a quartz-mercury lamp produced a change resembling vulcanisation. Oxygen was probably the chief catalyst for rubber in all the stages, from the photo-synthesis of caoutchouc in the latex to the final manufactured product. In the absence of actinic light the viscosity of rubber (solid or in solution) was not reduced. Rubber alone exposed to sunlight in sealed tubes set to a jelly which turned fluid again in a few days when the tubes were opened.

This last observation, Dr. H. P. Stevens remarked, was novel; moisture itself was not harmful to rubber, as Mr. Porritt had also stated. Dr. E. H. Rayner referred to the slow deterioration of ebonite by light which they had already studied for ten years at the National Physical Laboratory. They had not yet found an ebonite which was not affected by moist air in the light; though the moisture was not primarily responsible, it made it possible that a piece of ebonite placed between a copper penny and the iron knife allowed appreciable currents to flow. One of the points to be considered in this case was mentioned by Professor

A. W. Porter; light affects the resistance of sulphur, though less so than that of selenium.

PRECIPITATION IN DISPERSE SYSTEMS—CATAPHORESIS AND ELECTRIC OSMOSIS.

Opening the discussion of this technically most important branch of the subject which came on very late, unfortunately, Professor Alfred W. Porter, F.R.S., said that both cataphoresis and endosmosis took place when a liquid in contact with a solid was placed in an electric field. In cataphoresis the solid was in the form of a mobile suspension, in endosmosis in the form of a fixed porous membrane *in situ*. The motion in the direction of the field or in the opposite direction was due to the field acting upon the charges of the double layer at the interface between the solid and liquid; the charges were usually due to the differential adsorption of ions at the interface, but might be due also to the direct transport of electrons across the interface; in any case the motion ensuing was merely a question of hydrokinetics. The subject had fully been discussed by T. R. Briggs in the Second British Association Report on Colloids. At the late hour, Professor Porter contented himself with drawing attention to the very definite conclusions at which Mr. Mukherjee had arrived.

In this long paper on "The Origin of the Charge on a Colloidal Particle and its Neutralisation by Electrolytes," Mr. J. N. Mukherjee suggested that in most cases the charge of the particle was of the same sign as that of the ion which the substance had in common with the electrolyte. The fixation of that ion would be of the nature of the growth of a crystal in a solution. When sodium chloride crystallised, molecules of the solution would be most strongly attracted to certain spots of a crystal by the unsaturated forces of the boundary film. Ions were similarly fixed by "chemical adsorption" (which did not imply chemical affinity between ions of opposite signs) and they would in their turn bind ions of opposite charges from the solution, but the number of ions so neutralised would be small. If the ions (the chemically and the electrically adsorbed) were all univalent, they would not reverse the original charge; but polyvalent ions were able to do that, and Mr. Mukherjee showed (after Einstein) that the adsorption of different ions by a negatively-charged surface decreased in the order Th, Al, Ba, Sr, Ca, Mg, H, Cs, K, Na, Li, which was the order in which he and other experimenters had arranged the same ions as to their precipitating power, though the precipitation of suspensoids (Elissafoff and others) was a complicated process.

We can only mention the "Observations on Peptisation and Precipitation" by Messrs. N. G. Chatterji and N. R. Dhar, of Muir Central College, Allahabad. The point is that the hydroxides of the heavy metals are not precipitated by alkalis in the presence of glycerin or of concentrated sugar solutions; but this "peptisation" (non-precipitation) is not observed when the salt is added to the mixture of glycerin and alkali, instead of adding the alkali to the salt-glycerin mixture—technically an important point. Messrs. Chatterji and Dhar studied these phenomena by the aid of electrolytic conductivity; when new salts and new ions are formed, the conductivity of the solutions should rise, peptisation should leave the conductivity unchanged, and they confirm this by many experiments on various metals and further by some colour changes accompanying these phenomena, especially in copper sulphate and nickel and cobalt salts.

The difficulties of the experimental studies of colloidal phenomena, as well as their rewards, were well brought out in a paper by Mr. A. G. Lowndes on the "Abnormal Crystallisation of Lead Azide and Colloids." Lead azide, PbN_6, an initiator of detonation, Mr. Lowndes explained, was obtained by precipitating lead acetate or nitrate with sodium azide NaN_3. The lead azide crystallised in large complex crystals, looking like rods set on both sides with spikes, and the frequent explosions in azide works were ascribed—erroneously perhaps, he thought—to the breaking-up of large crystals, especially when the crystals resembled crossed needles. When crystal growth is watched under the microscope traces of colloids are very disturbing. Mr. Lowndes therefore suggested mixing the lead salt and the NaN_3 not in water, but in water containing 0.5 per cent. of glycerin. By studying hundreds of crystallisations, which he exemplified by photographs, he succeeded in reducing the coarse spikes into small grainy crystals, both in the laboratory and in the factory.

In his contribution to "The Theory of Precipitation of Disperse Systems" Dr. R. S. Willows, M.A., remarked that though much of the work on precipitation was questionable owing to the use of faulty methods, some of Zsigmondy's results were sufficiently definite for mathematical treatment. Zsigmondy counted the number of primary particles of red gold hydrosol; he added electrolyte until the colour changed into yellow-green by coalescence of several particles to secondary particles; he then stopped further coalescence by adding gum arabic and counted the particles again, making calculations after Smoluchowski. The electrolyte destroyed the double layer which previously prevented coagulation; Brownian movements then brought the particles into contact.

In the formula deduced Einstein's diffusion constant played an important part. Two points seemed to be established: (1) the stability of emulsions, at any rate, depended only upon the potential difference across the double layer (Powis), and (2) there was no relation between surface tension and viscosity.

Professor McBain's account of some quite recent experiments by Mr. W. F. Darke did not simplify matters. It was observed that the electrolytic conductivity of an aqueous solution of potassium chloride was 9 per cent. greater when measured in a capillary of fused silica, 0·25 mm. diameter, than when in bulk, and this extra conductivity was ascribed to the adsorption, by the silica walls, of chlorine ions, leaving potassium ions available for carrying the electrolytic current. That layer of chlorine, adsorbed by the surface of the vessel they calculated, was one molecule in thickness.

The communication sent by Professor H. Freundlich, of Göttingen, one of the best-known workers on colloids, on "The Potential Differences arising in Electro-osmosis and Allied Phenomena" concerned the fundamental problem of measuring the potential differences coming into play when liquids stream through capillary glass tubes. We had to distinguish between the ordinary potential ϵ metal/liquid of Nernst and the stream potential ζ which Freundlich was only able to determine with glass electrodes after Haber and Klemenciewicz. The two potentials were not identical and might indeed have different signs. Any solid surface was covered by a liquid film projecting into the liquid; the richer the liquid was in ions, the thinner would be that film; ϵ indicated the difference of potential between the solid wall and the liquid, ζ the potential between the film and the moving liquid. The point is very interesting also with respect to the theory of lubrication.

The account of "Some Applications of Electro-Endosmose and Cataphoresis," which Dr. W. R. Ormandy gave, showed that there is still little done in this field over here. With respect to the purification of clay we refer our readers to page 689 of our issue of May 21 last. It had been found possible to deposit 6,833 kg. of dry clay by 11·8 kw.-hours at 50 volts; if we regarded this endosmose as of the nature of galvanic deposition, that would mean that the current depositing 31·5 grammes of copper could deposit 700,000 grammes of clay. With the aid of diaphragms, permeable to soda but not to silicate solution, colloidal silica (up to 30 per cent.) was prepared in Germany from silicates, and had proved efficient for wound dressing. Therapeutically-valuable serums were similarly prepared. Two German electric tanneries worked with diluted tanning liquor and had found that the current consumption of 20 or 25-kw.-hr. per square metre could be reduced to 7 kw.-hr., if the tanning were completed in a strong liquor. In endosmotic ore separation the finely-ground ore was allowed to sink in a column of water, to which electrolytes were added and across which the current was passed; in this way iron was removed from clay. The purification of gelatin, the need of which had been emphasised by several speakers, was also effected with the aid of special diaphragms. Finally, Dr. Ormandy referred to oil and water; oil globules charged by adsorbing traces of inorganic salts passed to the anode, and oil emulsions and tars were largely dewatered by such means in California.

Coming to general considerations, Dr. Ormandy said that the theories of colloid precipitation and endosmose and the effect of electrolytes were all unsatisfactory. When we used water as medium, we were never free from ions, as Mr. Hatschek had already pointed out. Some, but not all, clays could be dispersed to particles beyond microscopical power. The clay particles would adsorb 1·5 per cent of caustic soda from alkaline solution, and boiling water would not wash out that soda. But if we put the particles in the purest water and applied an electromotive force of 1·6 volt (the dissociation pressure of NaOH), the soda was removed. That fact was entirely overlooked in U-tube experiments on cataphoresis, in which alkali would be set free, influencing the movements of the ions. The Brownian movements were also neglected in these considerations. It was further curious that clay particles of 3 μ diameter, suspended in caustic alkali, would cover themselves with Na-ions only over one-sixth of their surface. That was apparently the maximum charge the particles could carry; for under the microscope the particles were seen to burst when the alkali concentration was increased, and the bursting would repeat.

We should mention that the discussion with which we have dealt will be published *in extenso* by the Scientific and Industrial Research Department.

THE SEALING OF WATER HORIZONS IN OIL WELLS BY MEANS OF THE CEMENTING PROCESS.

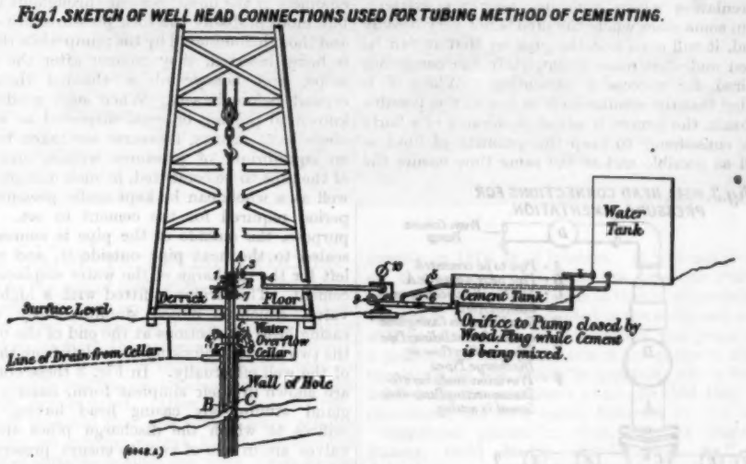
By A. A. DOWNS.

THERE are very few oil-fields which have no water problem peculiar to themselves, and still fewer without water horizons in the strata to be penetrated in the search for petroleum. Many promising areas have, in the past, been ruined by careless exploitation without proper care to exclude water encountered from the bore-hole, and in most countries special legislation has been enacted to ensure the protection of oil-horizons from water encroachment by way of the wells drilled. In established fields, the levels at which water may be expected are known, and the wells are drilled with a view to carrying what is known as the water string of pipe (which is usually of a special heavy quality with tapering screw joints) to the correct depth, where the operation of cementing is then carried out. The plant required for this operation is expensive; it consists of a string of steel tubing long enough to reach to the bottom of the well, and generally 3 in. in diameter, and a high-powered force pump together with the necessary connections. The pumps are generally of the duplex type and constructed to handle heavy muddy fluids efficiently, without getting out of order, but failing a special pump being available, a Worthington pump of sufficient power will give good results. Most operators prefer to have two pumps on hand for the work in case one breaks down, as even a short stoppage may be fatal to the success of the job, and even damage the well to a very considerable extent. The size of the pump depends on the amount of cement to be used and the depth of the well, and often on the condition of the latter, but generally speaking it should be capable of exerting a pressure of 700 lb., and putting through 50 barrels of cementing fluid in half-an-hour. When connecting the pump to the well, swing joints must be used in order that the well pipe or casing may be moved up or down without breaking the joints; the pump is connected directly to the tubing and the latter is connected externally to the casing by means of a special casing head, and all joints must be absolutely sound and capable of maintaining the pressure on the well when pumping commences. The casing head is fitted with a relief valve for a purpose which will appear later. The suction of the pump is connected to a water reservoir, which is preferably placed at a higher level than the pump, and another connection is made to the cement-mixing tank or reservoir, which must be above the pump in order to ensure a free fall of the thick liquid to the latter. Valves are so placed that

cement or water can be switched on or off as desired. In Fig. 1 all connections are shown in place and all essential parts are indexed. Beginning with the derrick; the floor is supported on beams above a cellar in which there is sufficient room vertically for the succession of pipes required to drill the well, each being set on clamps above its predecessor, but the pipe which is being cemented is fitted with a joint of sufficient length to bring it about 18 in. above the floor, so that it is easily accessible (this joint is removed when the cement has set and deeper drilling with the smaller pipe commences).

The elevators (7) are on wire rope slings and are lowered and raised by the casing pulley blocks shown above; the split gland stuffing-box (1) is designed to seal the annular space between the pipe and the cementing tube, and at the same time be of such construction that it can be removed in the shortest possible time, thus obviating the risk of cement setting around the foot of the tubing before the latter can be removed. For the same reason

Fig. 1. SKETCH OF WELL HEAD CONNECTIONS USED FOR TUBING METHOD OF CEMENTING.



1 Split gland stuffing-box, quickly removable.
2 Relief-valve.
3 Quick disconnecting joint.
4 Swing joint or flexible pipe.
5 Water-gate valve.
6 Cement-gate valve.
A. A. = tubing.
B. B. = pipe to be cemented.
Supported on :—
7_1 = elevators on slings ready to lower.
C. C. = Next outer pipe to B. B. on :—
8 = Casing clamps.
9 = Pump.
10 = Pressure-gauge.

the joint (3) must also be easily disconnected; a universal ball joint is very satisfactory for the purpose; the swing joint (4) may be constructed of a set of double elbow connections, having a little reserve of screw left in the fitting, to allow the casing and tubing to be raised and lowered a short distance without unduly straining the connections of the cement delivery pipe at either end, but a sufficiently strong flexible hose is, of course, better.

The cement tank may be built of wood, and, if possible, should be below the surface of the ground, but the arrangement of the external plant, such as pumps and tanks, must depend on the situation of the well and the ground immediately surrounding it.

Assuming that all the plant is on the spot and ready for connecting up, it is necessary to be certain that the well is in the right condition for cementing, and the first essential is to have the pipe to be cemented, perfectly free in the well, so that it can be lifted and lowered without difficulty. It is assumed that the formation at the bottom of the well is suitable. The pipe should be tested several times by lowering it to bottom and raising it again through several feet, and all being in order, the tubing is put in and the well head connected up to the pump. As soon as this is done the pump is started on water, which is circulated down through the tubing to the bottom of the well and up to the surface on the outside of the pipe, this further ensures the pipe being free, and washes away small obstructions, and the pipe is again tested while this is going on. The time has now come to mix the cement, and this must be done expeditiously, making the fluid quite thin and as easy as possible to handle with the pump. At the time of starting the cement into the well the casing should be about 18 inches from the bottom of the well, the water is cut off and the cement mixture taking its place, is forced into the well as fast as possible.

The quantity of cement is previously calculated, of course, and as soon as it is all exhausted, water is again turned on and a measured quantity pumped behind the cement in order to clear the tubing of the latter, and drive the cement behind, or to the outside of, the casing. The strata at the bottom of a hypothetical well are represented in Fig. 2, which shows the position of the pipes and tubing, and the cement below and behind the pipe, at this stage of the operation. Without stopping the pump, the casing is then lowered to the bottom of the well, where it closes the passage from the inside to the outside, and so retains the cement, behind itself. The pump, meanwhile, almost stalls, because of the sudden resistance due to checked circulation, and as soon as the pipe is safely on the bottom the relief valve is opened at the casing head, to relieve the pressure from the inside of the casing, connections are cast loose as quickly as possible, and the tubing withdrawn from the well.

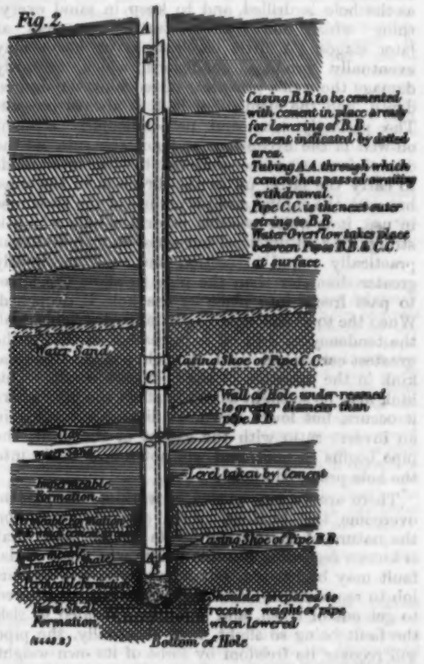
This completes the work, and the well is then left to stand for about a month to allow the cement to set. When the well is again taken in hand to drill down, a certain amount of set cement will be found inside the pipe, but this is easily drilled out in the usual manner. After drilling through, however, the well must be tested to make sure that an efficient seal has been placed, to do this, the water in the pipe is all removed, and the well allowed to stand for a day or two longer, when it is tested for the presence of water.

There is much disagreement as to which is the best type of strata or formation in, or on, which to cement. Clays are favoured by some, but there are strong reasons why most clays are unsound as a basis for a cement job, and the success met with in using them is very likely due in many cases to the fact that cementing was not necessary in clays of its class, since there are clays of such hardness and impermeability to the action of water that a satisfactory shut-off can be got by simply driving the pipe into them in a hole drilled smaller in diameter than the pipe. These are rare however, and the majority of clays and shales are such that water softens and crumbles them away, and if better strata for the purpose are not reached by the cement at a level below that of the water to be excluded, they are liable to cave and crumble below the cement, and eventually around the outer wall formed by the cement, for it must be remembered that cement does not bind with clay, and a sharp line of division must always remain between the two. On the other hand, sandstone often forms a very good basis, for as long as it is hard, it is not likely to crumble, and though it is permeable in varying extents to water, its cellular construction enables the cement to enter it until saturated, and bind to form a homogeneous joint.

The best class of formations, however, are what are known to drillers as "shells," these are streaks of especially hard stone such as limestone and sand rock, or marine deposit of a limestone nature. These shells are occasionally met with of great thickness, and in such cases are difficult to drill through, but as a rule they are only a very few feet thick, but as shell of even a few inches in thickness is the best of foundations for cementing upon.

In describing the testing of the pipe, it has been stated that it is lowered to the bottom and raised; not only is this the case, but its weight is allowed to bear fully on the bottom—a shoulder being prepared there to take its weight and prevent it sinking into, and becoming jammed in, the formation, as might happen if the hole was left tapering to a diameter smaller than that of the casing shoe. This shoulder is illustrated in sketch Fig. 2. At

Fig. 2.


Casing B.B. to be cemented with cement in place ready for lowering of B.B. Cement indicated by dotted area.
Tubing A.A through which cement has passed awaiting withdrawal.
Pipe C.C. is the next outer string to B.B.
Water Overflow takes place between Pipes B.B & C.C. at surface.
Casing Shoe of Pipe C.C.
Wall of Hole under-reamed to greater diameter than pipe B.B.
Level taken by Cement
Casing Shoe of Pipe B.B.
Bottom of Hole

the end of the operation, when the pipe is set on the bottom to exclude the water, a foundation likely to sink or crumble may allow the pipe to gradually go lower and lower while the cement is setting, and thus interfere with the binding of the cement and pipe. It may also give way to the pressure of the liquid cement on the outside of the pipe, and allow it to break through below and find its way back into the inside of the pipe before it sets.

In case of such a cementing job as described being unsuccessful in excluding the water, special means have to be adopted with the next attempt to cement, as it may be taken for granted that the pipe is bound by the cement already in the hole, and annot be lowered, and all subsequent operations are ery costly and tedious, so that it may be necessary to insert a new string of pipe inside the bound pipe in order to start again with a fresh attempt altogether, incidentally losing a string or part of a string of pipe, and reducing the size of the hole with the consequent reduction of the depth it is possible to drill to. Since each new pipe used, necessarily goes inside the one previous to it, and there are limits to the depth which can be gone through by a string, the friction of the strata increasing with depth until it overcomes the power which can be exerted to force the pipe in. The attendant risks make the operation a very interesting one, and necessitate the greatest care in the choice of plant and the condition of both plant and the well.

It will be readily understood that the insertion

and removal of the tubing is an operation which takes considerable time and labour, so that on fields where suitable high-pressure extra fittings are available, another method, differing mainly in that tubing is not used, is coming into favour. This method is necessary when abnormal conditions prevail, and will now be described in conjunction with some of the conditions the occurrence of which make it the only possible method to adopt.

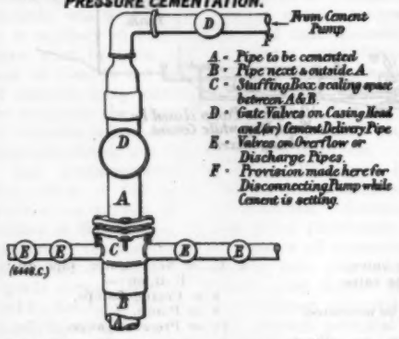
Practically all adverse conditions encountered in well cementing are due to the pipe or casing being out of easy control for reasons which may be due to the nature of the strata it penetrates, the presence of gas or water pressures, or to imperfect work while drilling the well, and of these the latter is much the commonest cause. It must be realised that the driller of an oil-well is in much the same case as a doctor attending a deaf and dumb patient through an illness, in that he has to ascertain, from his own knowledge and experience the exact conditions which arise as the hole is drilled, and to keep in mind everything which may affect further progress at later stages. A little carelessness or haste may eventually produce conditions which seriously damage the well's prospects of reaching the desired depth, and the element of luck is always present. The perfectly true and perpendicularly straight oil-well is the exception, and not the rule, as the dip of formations encountered by the tools tends to carry the latter off in the direction of the dips, but with the careful and proper use of the tools now in use, it is quite possible to drill a hole which is straight for all practical purposes, and, in addition, practically round in section and of a sufficiently greater diameter than the pipe to allow the latter to pass freely into place as the hole is deepened. When the tools encounter a strata harder than usual, the tendency to drill off is increased, so that if the greatest care is not used at such points, an actual kink in the direction of the hole may result. This kink may be so slight as not to affect the pipe where it occurs, but lower down, at distances varying in an inverse ratio with the extent of the fault, the pipe begins to bind, and will not follow freely into the hole prepared ahead.

There are various means of working the pipe to overcome this binding, which depend greatly on the nature of the general strata passed, and what is known regarding possible points where the initial fault may be located, but it is a long and tedious job to recover true direction in a hole once allowed to get out of truth, and it is often decided to risk the fault being so slight, that eventually, the pipe will recover its freedom by force of its own weight as it is lowered further into the ground, and means to force the pipe are adopted. In such a case, we have a well which lacks the first essential to success in cementing, the pipe being bound and not easily lifted and lowered as described *ante*. In these circumstances, when the cementing point is reached, the pumps are connected up to ascertain whether a circulation through the pipe to the bottom of the well and up the outside of the pipe to the surface, is present, and it will be found that if a circulation exists, it can only be maintained by the exertion of a pressure considerably greater than if the pipe were free, though in some cases it is at the outset not available at all.

The next step, therefore, is to improve the circulation where one exists, or to force one where there is none, and the connections which will be used later on for cementing are accordingly installed. The plant in question consists of the high duty pump, water and cement tanks and connections to the pump suction end, and, in place of the tubing, a set of special connections able to withstand the highest pressures which can be exerted by the pump, with a good margin of safety. These are fitted direct to the pipe to be cemented, connecting the latter with the delivery end of the pump, all joints are made as strong and perfect as possible, and the essential part, the valve or preferably two valves, which are to cut off the pump from the well at the end of the operation, must be of the very best procurable gate type. The connections are comparatively simple as no stuffing-box and swing joint are needed, they are embodied in sketch Fig. 3, and are those extending from "A" to "F." (Those below "A" illustrate a more complicated operation mentioned later.) Cement delivery pipe, "F," should be the largest size which can be fitted to the pump to ensure the fullest possible stream of cement to pass into the casing, and thus minimise dilution of the mixture with water as it goes to the bottom.

With this apparatus in place, circulation is commenced, and the water forced through the well gradually washes and scours away the detritus, which has fallen or been scraped, from the walls, and which blocks the passage. If a reduction in the pressure necessary to maintain a circulation is not obtained in this manner, connections are tried which seal the outside of the pipe to the pipe next to and around it, and water is forced through in the reverse direction, *i.e.*, down the outside of the pipe and up the inside, and by working in this manner, a comparatively free circulation may be obtained, and at least some improvement in the conditions for cementing. This will often create a circulation where such has been non-existent, and in some cases where the pipe is not very heavily bound, it will even free the pipe so that it can be moved and thus restore completely the conditions required for successful cementing. When it is decided that the circulation is as free as it is possible to obtain, the cement is mixed, preferably of a fairly thick consistency to keep the quantity of fluid as small as possible and at the same time ensure the smallest amount of dissemination of the cement into the water standing in the pipe, the pumping or circulating water is cut off and the cement is introduced into the pump, which forces it into the well, where it quickly reaches the bottom and begins to mount up on the outside of the pipe, the water it displaces being above it. A measured quantity of water, about 25 per cent. in excess of the volume of cement fluid pumped, is next pumped in and the valves of the well-head connections tightly closed to maintain the pumping pressure, before the pump is stopped.

Fig. 3. WELL HEAD CONNECTIONS FOR PRESSURE CEMENTATION.



The position of the well is now as follows:—The pipe is full of water and sealed at the top with the special valves. Cement fluid is at the bottom of the hole and up the outside of the pipe for a considerable distance, but is prevented from returning into the pipe by the water which cannot be displaced. Above the cement outside the pipe there is also water, and if all joints are perfect, and no extraneous conditions interfere, the cement is locked in place and can safely be left to set for the required period of, say, 30 days, when it is opened out to test. It is possible to get connections and joints only relatively perfect, however, and a certain amount of leakage is probably present which allows part of the cement to return to the casing, while some cement has probably been suspended in the water inside the pipe and at the cessation of pumping, it settles to the bottom. Because of these normal losses, it is necessary to make a good allowance when calculating the amount of cement required, and to use only cement of first-rate quality and of as quick setting a type as can be got.

The binding of a casing may, of course, have been caused by other circumstances than lack of straightness in the bore, such as loose formations which will not stand up but crumble away into the hole, filling and packing the space between the wall and the pipe, or by boulders falling and jamming the pipe, though in the latter case, the pipe is generally bruised in, and what has occurred soon becomes known, and measures to repair such damage are taken. Very occasionally it occurs owing to an attempt to carry a string of casing with an abnormal amount of wall friction, as every foot the pipe is carried below the bottom of the next pipe outside it, increases the frictional surface, and will eventually check the pipe despite its weight.

Other serious complications are caused by pressures of gas and water in the hole, and though these are comparatively easily overcome when the pipe is free, when met with in conjunction with a bound pipe, they make the job much more liable to failure. The action of such pressures depends greatly on the depth of the strata where they originate, as compared with the depth of the pipe, and if near the foot of the pipe, their action appears to be such as to partly negative the cement lock which should exist at the close of the operation. Possibly these pressures act by maintaining intermittent channels in the liquid cement throughout the work, but more probably the rock pressures are constant, and though dominated by the pump while the cement is being inserted, they recover after the pumping stops, and honeycomb a channel through the cement before it sets. When such conditions are known to prevail, or even suspected as a possible obstacle to success, measures are taken to provide an equilibrium of pressures within, and outside, of the pipe to be cemented, in such manner that the well as a whole can be kept under pressure for the period required for the cement to set. For this purpose, the outside of the pipe is connected and sealed to the next pipe outside it, and an orifice left for the discharge of the water displaced by the cement. This orifice is fitted with a high-pressure valve, which is closed simultaneously with the casing-head connections at the end of the operation, the two together blocking all outlets from the bottom of the well effectually. In Fig. 3 these connections are shown in their simplest form, namely, a split gland stuffing-box casing head having overflow orifices to which the discharge pipes are fitted; valves are in sets of two, to ensure preservation of pressure.

In cementing operations of the kind described, there are a number of details of practice which are in favour with many operators, who have much faith in their efficiency, but most of these tend to complicate the work without any reasonable recompense. One of these is to use a plug of wood and rubber as a piston behind the cement in its course down the pipe; it is introduced by means of a trap made to form part of the casing-head connections, and set in motion at the point when all the cement has left the pump and the water is turned on.

The idea is to ensure non-dilution of the cement fluid with the water in the pipe, and prevent any from being left suspended in the water, and to form a solid ram to force the cement behind the pipe. Such a piston cannot be made of a close enough fit to be effective, and at the same time be free from liability to jam, whilst the extra connections used to make the trap are all potential leaks, and actual complications of an already sufficiently delicate operation.

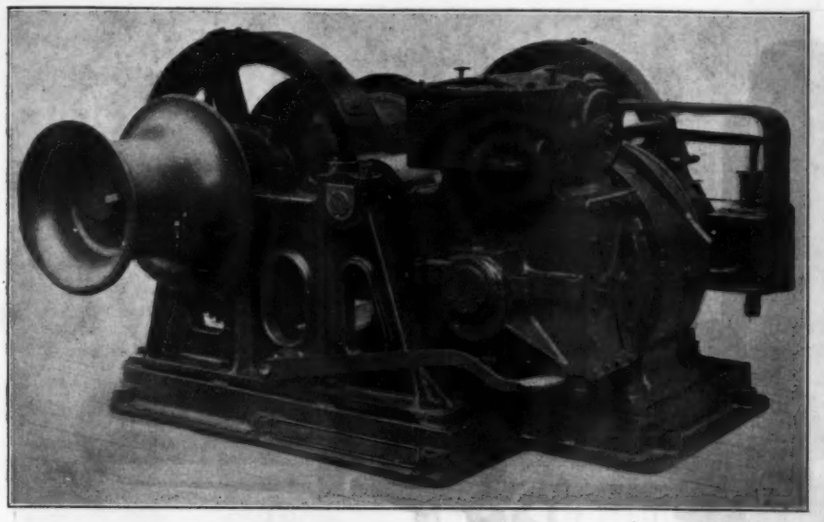
Where circulation cannot be obtained at reasonable pressures it is useless to continue with the plan of cementing, and means have to be adopted to remove the pipe from the well or far enough up the well until it is once more free; the hole is then straightened out if possible, but with casing bound so fast, this also is probably impracticable, and the pipe is accordingly cut at the point of binding with tools specially constructed for the purpose, pulled up, and the hole re-drilled past the pipe lost in the hole, when another attempt may be made to cement the string.

Unless something of this kind be done, the only alternative is to insert another and smaller string of pipe than was originally intended to be the water string. In any case, therefore, failure to cement successfully is a very costly matter in work or pipe.

THE ENGINEERING TRAINING ORGANISATION.—In a former issue (see page 314 *ante*) we gave a brief account of a meeting of this organisation on the subject of its winding up. We are now informed that the Engineering and National Employers' Federation has undertaken to carry on the work of the organisation.

ELECTRICALLY-DRIVEN 3-TON CARGO WINCH.

CONSTRUCTED BY MESSRS. JOHN H. WILSON AND CO., LTD., ENGINEERS, BIRKENHEAD.



MARKING OF PATENTED ARTICLES.

Prior to the Act of 1907, there was no obligation on a patentee to mark on his articles any indication that they were covered by letters patent. Many preferred so to mark the articles, and the difficulty in the history of litigation appears to have been to prevent people putting on articles marks to which they were not entitled. After the Act of 1907, it was not essential that one should mark articles made under an existing patent, but it was enacted that unless suitable notification were given to the public as to the existence of the patent, the patentee could not recover damages in respect of any infringement from any defendant who proved that at the date of the infringement he was not aware, nor had reasonable means of making himself aware of the patent. This deals with articles manufactured under a patent in force, but the difficulty sometimes arises as to what is to happen when the patent has expired. Very few cases have been reported to aid one in deciding the point, but one of these may be of interest, together with references from a different Act which affects the matter, namely, the Merchandise Marks Act of 1887. The position is not altered by the latest Patents and Designs Act of 1919. The Patents Act of 1907 and the Merchandise Marks Act of 1887, therefore, control the position as to the marking of patented articles.

The Merchandise Marks Act enacts that every person who applies any false trade description to goods shall, subject to the provisions of the Act, and unless he proves that he acted without intent to defraud, be guilty of an offence against the Act. The expression "trade description" means any description, statement or the like as to any goods being the subject of an existing patent, privilege or copyright. Here it will be noted that reference is made to the fact that the patent must be an existing patent, that is, it must still be in force.

The Patents and Designs Act, 1907, in addition to the enactment relating to the exemption of an innocent infringer from liability for the damages referred to above, provides that if any person falsely represents that any article sold by him is a patented article, he shall be liable to be convicted for this offence under the Summary Jurisdiction Acts. The section defines to a certain extent, how this false representation may be made, namely, by having stamped or otherwise marked on the article the word "Patent" or "Patented"; in other words, expressing or implying that the article is patented. No specific provision is made in this Act as to the effect of the expiry of the patent.

On this point a case decided many years ago, namely in 1876, is of interest. It was not decided on the present Acts, but the previous Statutes contained similar provisions so that in all probability the line of argument adopted in the early case would still be available. In this action, two years after a patent had lapsed, the son of the patentee altered the labels on the article in question, which beforehand bore the patentee's name, so that they then introduced his own name, followed by the words "Improved patent"; thus, G. C.'s Improved Patent, Gold Medal, Self-Cleaning, &c." The defendants, who had been in his employ, set up business in the same town some years after and sold similar articles inscribed with the original label, namely "S. C.'s Patent, Prize Medal, Self-Cleaning, &c.," with an indication after that they were manufactured by W. & Co. The Court of Appeal, reversing the Vice-Chancellor's decision, held that the label used by the plaintiff, that is the son, was not a trade mark, but only a description of the article as made according to the original patent common to all the public; there was nothing in the defendants' label calculated to mislead, and that the plaintiff's label, as a whole, constituted a false representation, that the patent was still subsisting, and disentitled the plaintiff to relief by injunction. From this case, and from the references to the Acts, it would appear that any marking applied to articles must not lead one to the conclusion that they are covered by a patent in force if the patent in fact is not an existing patent.

ELECTRICALLY-DRIVEN 3-TON CARGO WINCH.

An example of a recent model of electrically-driven cargo winch which is being built in large numbers by Messrs. John H. Wilson and Co., Limited, of Dock Road, Birkenhead, is illustrated above. The winch has a lifting capacity of 3 tons at 80 ft. per minute, and can deal with lighter loads at correspondingly higher speeds, the speed change being obtained by series-diversion of the motor. As the winch is intended for use on shipboard, its motor and switch are watertight and are able to stand submersion by breaking seas without injury. The resistances and main controller, which is of the relay type, are enclosed in a ventilated cubicle suitable for mounting in a protected position in a deck-house, or below deck. No-volt and overload releases are fitted. The operating voltage is 220 continuous current, and the motor will develop 22·5 brake horse-power at a speed of from 450–675 r.p.m., with a temperature rise not exceeding 81 deg. F. A slipping clutch is fitted between the armature and the spindle.

The general appearance of the winch is well shown in our engraving. As will be seen, it follows broadly the familiar lines of the steam winch, and has a cast-iron barrel and warping drum. The barrel is 22 in. and the drum 18 in. in diameter. The barrel is driven from the motor by a train of spur gearing with an intermediate shaft, pinions being of mild steel and spur wheels of cast-iron. All teeth are machine-cut and shafts are of mild steel. A flat type band-brake operated by a foot-lever is fitted, and is interlocked with a limit-switch controlling the motor, so that the motor stops when the brake is applied. A centrifugal brake is also fitted to prevent excessive speeds at light load, or when lowering. There is, in addition, a magnetic solenoid brake which holds the load when the operating switch is moved to the off position, or in case of failure of current. A further electrical feature is a load discriminator, which is combined with the main controller to give automatic regulation of speed corresponding to the load lifted. There is no mechanical speed-reduction gearing in the winch and a range from dead-slow to full speed is obtainable with the electrical arrangements. The electrical parts of the winch were supplied by Messrs. Lawrence Scott and Co., Limited, of Norwich.

Duddell Memorial.—The wish has been generally expressed that there should be a memorial to the late Mr. W. Duddell, C.B.E., F.R.S., whose death in November, 1917, we recorded at the time (Engineering, vol. civ, page 497), giving a full account of his career. It is proposed that the memorial should take the form of a medal to be awarded periodically by the Council of the Physical Society, and at its discretion, to those who have advanced physical knowledge by the invention or design of scientific instruments, or of materials used in their construction. If sufficient funds are available after paying for the cost of the dies, and after providing for the cost of striking the medals, it is proposed to form a fund to be devoted to the foundation of scholarships or prizes to be awarded to students of the Physical Society under conditions to be determined by the council. Subscriptions should be forwarded to the Hon. Secretary, Mr. Robert S. Whipple, 15, Creighton-avenue, Muswell Hill, London, N. 10.

Analysis of Aeroplane Wing-Truss Stresses.—A report recently issued by the United States Advisory Committee for Aeronautics is concerned with the analysis of the effect of redundancies and particularly of the external drag and stagger wires. The stresses in a typical training machine have been worked out for several conditions of flight, the method of least work having been applied, as an illustrative case. The chief conclusions reached are that the use of more than one external drag wire on each side is wasteful and undesirable, that the effect of the stagger wires in speed diving is important and serves greatly to reduce the load in the lift trusses, and that the advantages in reduction and uniformity of stresses to be gained from the tensiometer in practical rigging are great enough to justify the general introduction of that instrument. In particular the stress wires are usually set up much too tightly. A copy of the report may be obtained upon request from the National Advisory Committee for Aeronautics, Washington, D.C., U.S.A.

Queensland Railway Policy.—At the official opening of a further section of the North Coast railway line in Queensland recently, the Minister for Railways made an interesting announcement on the Queensland Government's railway policy. The new section was from Styx River to Wumalgi, and after referring to the advantages which would accrue from the completion of the whole coastal line, the Minister said it was estimated that the section to Mackay would be opened in August next year, to Townsville, in March, 1922, and Cairns 1923, which would enable passengers to travel right through from Perth to Cairns, over 4,000 miles. He touched on the difficulties which had been experienced in securing rails and cement, and stated that of the total distance of 645 miles from Rockhampton 58 miles had been constructed before the construction of the North Coast line had been commenced. Since then 263 miles had been constructed, and 119 miles of tramways taken over, 205 remaining to be built. The total cost of the railway to date was 2,500,000*l*., and the estimated cost to complete the line was 13,000,000*l*. With the opening of a section on the Mackay end to Carmilla Creek they would then have 5,700 miles of railway in Queensland. They had invested 45,700,000*l*. in railways. The revenue of last year was 4,935,600*l*., an increase of 953,000*l*. on the previous year. In referring to what he termed unfair criticism levelled at the Railway Department, Mr. Larcombe said it had been stated that the department had shown a deficit during the last two or three years. He wanted to remind them that before the present Government came into power, the accumulated deficit on the railway service was 3,000,000*l*. He wanted to remind them also that other States of smaller area and larger population, like Victoria, had also had railway deficits. With a railway department there were other features besides making profits. It was an excellent thing to balance the ledger, and the railway department was constantly endeavouring to do this, but there were other factors more important than balancing the ledger. They wanted to fully and suitably develop that great State, and to prevent a constant rush to the cities. They wanted people to go out and take up land and increase wealth and production; but if they were to increase fares and freights every time the ledger did not balance, they were not going to discharge this important responsibility. The main lines of Queensland had paid exceedingly well. The deficiency which had accrued was due to the agricultural lines.

5-FT. UNIVERSAL RADIAL DRILLING MACHINE.

CONSTRUCTED BY THE NILES-BEMENT-POND COMPANY, NEW YORK, N.Y., U.S.A.

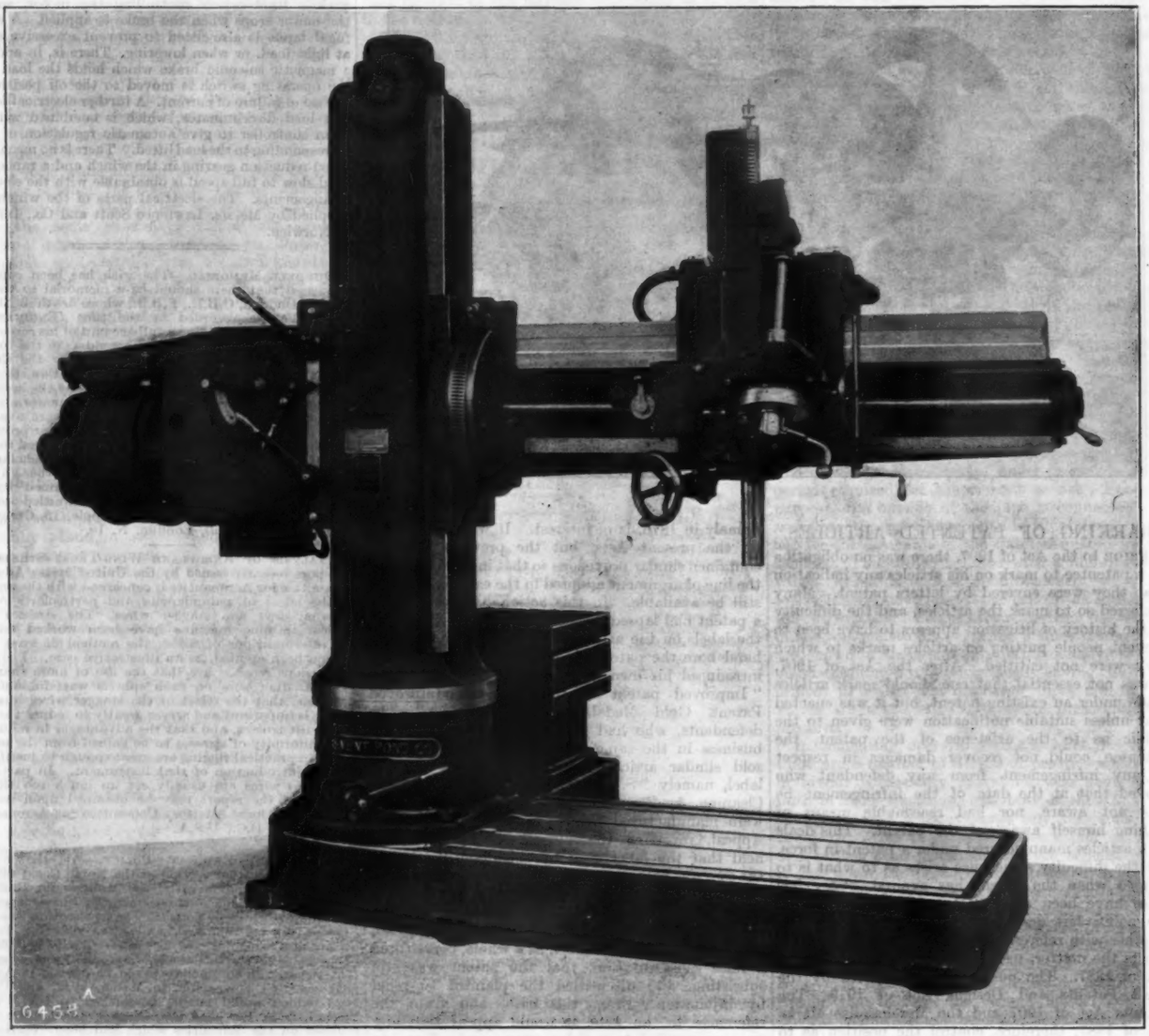


FIG. 1.

A NEW design of radial drill has been brought out by the Niles Bement Pond Company, New York, U.S.A., whose London offices are 25, Victoria-street, Westminster, S.W. 1. This is illustrated in Figs. 1 to 6 on the present and opposite pages, the "universal" pattern being shown, though plain drills are also made. The difference is that in the former the arm can be swivelled for angle drilling and the spindle swivelled on the saddle, which movements are not possible in the plain pattern. The design presents numerous interesting details, of which the chief perhaps is the type of column. This column is formed of two hollow box-sectioned members joined at the head and base, mounted on a pedestal on the bedplate. The two views reproduced in Figs. 1 and 2, on the present and opposite pages, give a good idea of the general appearance of this column, of which a cross-section is given in Fig. 3, and a detail of the base in Fig. 4.

The lower end of the column is fitted with two sets of roller bearings, one ring of large diameter and the other at the bottom of small diameter. The weight is taken on a thrust ball bearing at the bottom end of a vertical rod which houses a steel spring passing under internal lugs in the column. The load on this spring is adjustable. The form of column enables a direct drive to be obtained with the motor mounted on a back extension of the arm. All the movements are obtained from a single horizontal shaft, which is provided with back gears. This method of driving eliminates a large number of gears and auxiliary shafts. The arrangement of the motor on the arm extension helps to balance the parts to be rotated, thus tending to ease of movement of the arm in the bearings at the column foot. The arm is of new design and the lower guide is set well back, a feature which enables the spindle to be brought close to the driving shaft. A section of the arm, with the saddle mounted upon it is shown in Fig. 5.

If fitted with a constant-speed motor of 10 h.p., with an approximate speed of 1,160 r.p.m., the spindle speeds range from 13 r.p.m. to 452 r.p.m., in 32 changes. The drill can also be arranged with variable speed motor. The feeds provided are eight in number, varying from 0·006 to 0·06 per revolution of the spindle. The main drive is conveyed to the spindle by bevels on the driving shaft and spindle, and an intermediate double-faced bevel pinion. The feeds are changed by means of a graduated disc on the left side of the saddle. The feed change gears run in oil. Rapid vertical traverse of the spindle is secured by the knob lever at the lower end of the inclined spindle shown in Figs. 1, 2 and 5. When this lever is pulled down, the power feed is engaged. The fine hand feed is by the hand wheel on the right of the saddle, Fig. 1. The lever at the extremity of the vertical spindle on the right of the saddle, is for starting, stopping, reversing and changing speed. The traverse of the saddle on the arm is by the hand wheel to the left of the saddle, Fig. 1. This hand wheel is hinged and can be swung out of the way when the spindle is swivelled on the saddle.

The reverse for tapping is obtained by reversing the motor. An automatic feed trip is provided with graduated scale for depth drilling. On the feed change lever spindle are two graduated discs, one fixed to the spindle, and one adjustable by means of a knurled knob below, Fig. 1. The adjustable disc is set to the required depth. It carries a stop which automatically trips the feed clutch. The arm is raised and lowered by engaging the drive from the motor with a vertical screw in the column, Fig. 6. This drive can only be engaged when the arm is unclamped. The arm is clamped by two levers shown pointing upwards in Fig. 1, to the left of the column. These two levers have to be swung up into the unclamped position before the third lever shown between them can be moved. The latter is coupled to the vertical link extending between the two clamping levers. On each of the latter is a slotted boss, and on the vertical link are two pins. Only when the clamp levers are in the unclamped position are these pins free to enter

5-FT. UNIVERSAL RADIAL DRILLING MACHINE.

CONSTRUCTED BY THE NILES-BEMENT-POND COMPANY, NEW YORK, N.Y., U.S.A.

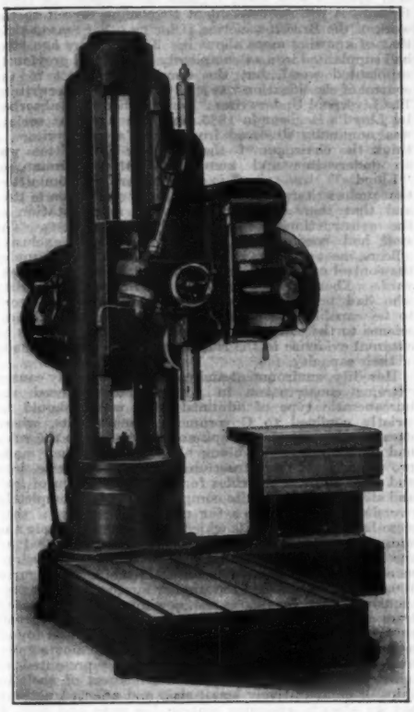
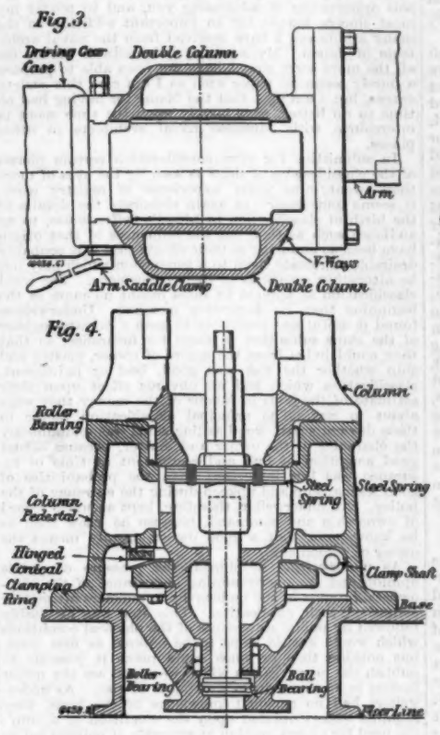
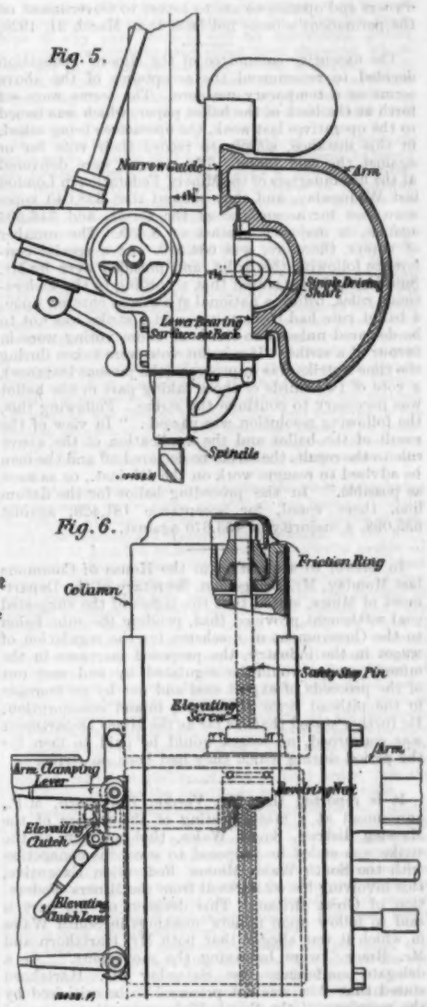


FIG. 2.





the slots on their bosses, thus allowing the link and the clutch lever to be moved. An automatic stop prevents vertical over-running, either up or down. This will also stop the arm should the spindle meet with an obstruction in lowering. In the machine illustrated the column is clamped by the lever at the base. These machines are further fitted with an electric column clamp not, however, shown in our illustrations. The clamp consists of a conical clamping ring shown in Fig. 4. When this is contracted by hand or power the column is pulled down hard on to the broad supporting face of the base, when the roller bearings are relieved of side strains during drilling operations. When the electric clamp is fitted the same clamping ring is used operated by worm from a small electric motor, controlled from the saddle.

The drilling machine we have described is made in two sizes, the radius of the arm being 5 ft. and 6 ft. respectively. The maximum distance from spindle nose to base is in the smaller size 68 in. and in the larger 78 in. The minimum distance in both cases is 12 in.

INDUSTRIAL NOTES.

THE terms of the provisional agreement between the Government and the Miners' Executive were announced last week. They are as follows:—

1. Recognising that on the increased production of coal there depend not only the prosperity of all who are engaged in the coal industry but also the welfare of the nation and the cost of life of the people, and having in view that this urgent need can only be met if the miners and mineowners throughout the country work together cordially for this common purpose, and, further, having regard to the necessity of setting up machinery for regulating wages in the coal trade so as to get rid of present anomalies and provide against future difficulties, the Mining Association and the Miners' Federation solemnly pledge themselves to make every effort to achieve these objects. To that end they shall: (*a*) Co-operate to the fullest extent to obtain increased output, and for this purpose will arrange to set up district committees and a national committee. (*b*) Proceed forthwith to prepare a scheme for submission to the Government at the earliest possible moment, and not later than March 31, for the regulation of wages in the industry, having regard, among other considerations, to the profits of the industry and to the principles upon which any surplus profits are to be dealt with.

2. Pending the preparation of the scheme referred to in 1 (*b*), wages shall be regulated on the following basis, without prejudice to the ultimate scheme above-mentioned: (*a*) An advance of 2*s.* a shift to persons of 18 years of age and over, 1*s.* to persons of 16 and 17, and 9*d.* to persons under 16, will be paid from the date of resumption of work to the classes of colliery workers entitled to the Sankey wage, and subject to the conditions under which the Sankey wage is payable. (*b*) For the purposes of this temporary arrangement the advance referred to shall be automatically adjusted on the basis set out below from January 3, 1921, in the light of the results of the five weeks ending December 18, and, similarly, from January 31, and thereafter every four weeks on the results of the four weeks immediately following the last preceding test period, but the Christmas holiday week shall not be counted in any such period, and an adjustment will be made in those cases where the holiday period falls wholly or partly within the New Year week. The basis on which the advance shall be adjusted is as follows: If the weekly average of the proceeds of export coal during the test period are maintained at the weekly average of the proceeds of export coal during the September quarter, the advance shall be 1*s.*, 6*d.* and 4½*d.* respectively. If (after deduction of the cost of extra output) they exceed the September figure, an additional 6*d.*, 3*d* and 2½*d.* respectively will be paid for every complete 288,000*l.* of the excess. (*c*) For this purpose the amount of export coal in each period shall be assumed to be the excess of the tonnage produced over the rate of 219,000,000 tons annually. The proceeds shall be calculated by multiplying that excess tonnage by the average f.o.b. price as shown in the trade and navigation accounts for the quarter ended September 30, 1920, and the cost of extra output shall be taken as 15*s.* per ton for each ton produced in excess of the rate of output for the quarter ended September 30, 1920. (*d*) As part of the settlement hereby concluded the Government undertake to make an Order under section 3 of the Mining Industry Act, which shall provide for the variation of the one-tenth share of the excess profits of the industry payable to the owners under the Coal Mines (Emergency) Act by the deduction therefrom or addition thereto of one-quarter of the said tenth part for each 6*d.* by which the men's advance is reduced or increased. (*e*) The certificate of the Secretary for Mines as to the amount of the proceeds and the advances payable shall be accepted as final.

The advance of 2*s.* per shift for workers above 18 years of age, 1*s.* for those between 16 and 18, and 9*d.* for those below 16, is to be paid from the date work is resumed. It is guaranteed by Government until December 31, in any event, and the January wage is to be the same as that for December if values from export sales exceed the values of the average export proceeds for the September quarter by a sum sufficient to cover the full wage advance. The period taken to ascertain the increased values for regulating the January wages is the five weeks ending December 18. If the increased values during the above period are less than the amount required to continue the advance in January, then for every 288,000*l.* less than the full amount required a reduction of 6*d.*, 3*d.* and 2½*d.* for adults, youths and young persons respectively will take place on January 3. The following table gives the minimum output, increased values and corresponding advance in wages per shift for adults:—

Output. Tons.	Increased values. £	Advance. *s.* *d.*
238,000,000	0	1 0
242,000,000	288,000	1 6
246,000,000	576,000	2 0
250,000,000	864,000	2 6
254,000,000	1,152,000	3 0
258,000,000	1,440,000	3 6
262,000,000	1,728,000	4 0

Further, for every 6*d.* reduction per shift in wages, the owners lose a quarter of their profits above the guaranteed profits, and for every advance of 6*d.* in

wages their profits in excess of their guaranteed standard will be increased by a quarter. The Government guarantee export prices at the figure of 72s. per ton, whether they rise above or fall below this figure. The scheme is a temporary one, to continue only until a National Wages Board is established. The owners and operatives are to report to Government on the permanent scheme not later than March 31, 1920.

The executive committee of the Miners' Federation decided to recommend the acceptance of the above terms as a temporary measure. The terms were set forth at the back of the ballot paper, which was issued to the operatives last week, the operatives being asked, in this instance, simply to record their vote for or against the said terms. The returns were delivered at the headquarters of the Miners' Federation in London last Wednesday, and they showed that 338,045 votes were cast for acceptance of the terms, and 346,504 against, a majority against of 8,459. The number of voters, therefore, was 684,549. At a special conference following the ballot, and presided over by Mr. Smillie, the latter stated that according to the Federation's rules, before a national strike was entered upon, a ballot vote had to be taken, and a strike was not to be declared unless two-thirds of those voting were in favour of a strike. If a ballot vote were taken during the time a strike was in progress (the present instance), a vote of two-thirds of those taking part in the ballot was necessary to continue the strike. Following this, the following resolution was passed: "In view of the result of the ballot and the application of the above rule to the result, the strike be declared off and the men be advised to resume work on the 4th inst., or as soon as possible." In the preceding ballot for the datum line, there voted, for acceptance 181,428, against 635,098, a majority of 453,670 against.

In answer to a question in the House of Commons last Monday, Mr. Bridgeman, Secretary of the Department of Mines, stated that the terms of the suggested coal settlement provided that, pending the submission to the Government of a scheme for the regulation of wages in the industry, the proposed increases in the miners' wages would be regulated by and met out of the proceeds of export coal and not by an increase in the pithead price of coal for inland consumption. He further stated that, as far as the Mines Department was concerned, no wages would be paid to men for the period during which they had been on strike.

It is reported that Mr. Vernon Hartshorn, M.P., announced at a mass meeting of the miners of the Maesteg district, South Wales, that as soon as the strike was ended he proposed to sever his connection with the South Wales Miners' Federation Executive, this involving his withdrawal from the Miners' Federation of Great Britain. This decision on his part is said to follow upon miners' meetings in South Wales in which it was alleged that both Mr. Hartshorn and Mr. Brace "were betraying the movement." At a delegate conference last Saturday Mr. Hartshorn stated that "he was not prepared to be criticised by the members of the South Wales executive, some of whom it was a degradation to sit with." Mr. Hartshorn has been asked to reconsider his decision.

In a written reply in Parliament last Monday, Sir Eric Geddes stated that the miners' strike had involved a serious loss of railway revenue, estimated at from 2,000,000*l.* to 3,000,000*l.* a week, and, even if work was speedily resumed, the loss of traffic and dislocation of industry must continue to affect railway returns adversely for some time to come. Other factors, such as the operation of the sliding scale for wages and the general trend of prices, must also be taken into account, and in all the circumstances he saw no prospect of any reduction in railway charges in the near future, but the whole position would be most carefully reviewed.

We read in the *Labour Gazette* that returns have been received from 80 of the principal urban districts in the United Kingdom (exclusive of the county of London), giving the estimated cost of buildings for which plans were passed in the third quarter of 1920. The following figures apply to the said quarter, those between brackets applying to the third quarter of 1919:—Total estimated cost, 9,643,306*l.* (7,140,450*l.*); of which 4,952,647*l.* (1,706,095*l.*) covers dwelling-houses. These figures show that the proportion devoted to dwelling-houses has enormously increased, thus refuting the allegation, frequently made, that luxury building was encouraged.

The London Iron and Steel Exchange, Limited.—The secretary states that most of the export orders which have come into the market of late have been taken by Continental manufacturers, "whose prices are pounds below those of British makers."

CLASSIFICATION OF SHIPS.*

By Mr. J. Foster King, C.B.E., Chief Surveyor of the British Corporation Registry.

Mr. President and gentlemen, permit me to express, however imperfectly, how very greatly I appreciate the courtesy which prompted your society to offer me this opportunity of addressing you, and to tender my most sincere thanks for an important addition to the many kindnesses I have received from the naval architects of Japan. My sense of indebtedness makes me all the more sorry that I have not been able to prepare a purely technical paper such as I am sure this society craves, but I am glad that the blame for having had no time to do better, rests largely upon the time spent in intercourse with Japanese naval architects in other places.

In submitting for your consideration certain phases of the classification of ships as seen by the eyes of more than twenty-nine years' experience of registry work, it seems unnecessary to again elaborate the details of the birth of classification in Lloyd's coffee-house, to an audience such as this, but the influences of that origin have been so enduring in their effects that it is probably desirable to restate them to a generation which may not be altogether conscious of their persistence. The word classification as applied to ships meant no more in the beginning than its dictionary meaning. Underwriters found it useful and profitable to keep a private register of the ships submitted to them for insurance, so that they could judge from the record of owner, master and ship whether the risk was good, bad or indifferent, classification which had an obvious effect upon their estimate of the odds in favour of the money they were about to risk. The principal classification factor in these days of small, wood sailing ships was undoubtedly the character of the owner and master, because actual good condition of hull and equipment at time of insurance was less important than the probabilities of good seamanship and upkeep during the currency of the policy. An underwriter, therefore, kept accurate record of ownership and command, because he knew then as he knows now that a good owner usually means the owner of a good ship.

As underwriting developed, the pressure of public opinion and the overwhelming importance of the shipowners' interest in the underwriter's registers ultimately compelled their publication. This step was inevitably followed by public statements of the physical conditions which would entitle ships to be entered as first class, but nothing then or since could make it possible to publish the moral values which were and are the major factors in an underwriter's estimate of risk. As underwriters had no personal knowledge of the facts, they required expert opinion upon the condition of a ship; the need for expert opinion at renewals of policies led to the convenience of stating conditions for regular survey; the convenience of not having to open up after completion led to surveys at one or two stages of construction; the preference given to the work of some builders compelled statements to others of the qualities which secured that preference, so that when underwriters started their private records of qualities, they unconsciously put in motion the machinery for controlling the construction and upkeep of such merchant ships as sought insurance. Human nature being what it is, matters which affected other interests so strongly could not long be left in the hands of one interest. Underwriters were therefore forced to yield to pressure and to accept shipowners and shippers as coadjutors in the administration of matters in which they were so vitally interested. It is to be feared, however, that underwriting considerations and a feeling of virtuous self-protection against the machinations of the wicked shipbuilder were in the forefront of their thoughts and action as classifiers.

During the age of wood shipbuilding registration advanced so far on the road to control, that the rules for survey were quite elaborate, and full explanations were given of the conditions expressed by the symbols showing whether a ship was regarded as good, bad or indifferent. Variations in age, condition and material involved the use of a great variety of symbols which had the broad effect of dividing ships into grades of quality and expressing their probabilities of life in terms of years. The latter could in no sense be an expression of actual expectation of life, as from the nature of things, wood ships are subject to destructive natural causes beyond the control even of classification societies, but they did express the interval between special surveys, which might be as great as ten years in a ship holding a twenty-year class. It is doubtful whether control of the actual building of wood ships ever reached the importance attached to that of periodical surveys; certainly at their highest development periodical survey rules were much more elaborate and definite than those for construction. Scantlings were stated in terms of tonnage and were doubtless a sufficient expression of good shipbuilding practice, in days when ships were small, proportions fairly constant and mid-sections large in proportion to length. These scantling rules have been an unfortunate legacy from which succeeding generations are not yet free, the building methods which they embody still linger in our thoughts and sometimes in our actions. We still speak of "working" in a familiar way in connection with homogeneous steel structures; even yet steel is massed in the places where wood keels and keelsons used to be massed in a valiant endeavour to give efficiency to non-homogeneous structures, and the trail of the tonnage rule is still to be found in modern numeral systems. Perhaps it is a pity that wood was so completely supplanted by iron and deprived of the chance of being developed with the aid of modern science.

* Paper (slightly abridged) read before the Japanese Society of Naval Architects in Tokyo, May, 1920.

Certain war developments prove that modern conditions do not evolve successful wood steamers from unscientific structural designs, but they also prove in the case of the flying boats that scientific design can make successful wood structures of less weight than was practicable with steel.

As it will generally be agreed that modern classification systems took their highest development in Great Britain, it will be convenient to confine myself to the work of the British societies, if for no other reason than that of knowing more about it. Thirty years ago steel had supplanted iron as completely as iron had previously supplanted wood, but the dominant interest in the control of classification was still that of the underwriters. The Liverpool Underwriters' Registry had been absorbed by Lloyd's Register in 1885, and although that society was nominally divorced from Lloyd's underwriters, I think the chairman of the Register Committee was an underwriter and knows that the chairman of "Lloyd's" was *ex-officio* a member of committee, that underwriters were in the majority on the committee, and that there was practically no representation of the constructional side of shipping interests. The staff had become a large organisation of exclusive officers, most of whom were dockyard men or were under the control of men who had been trained in H.M. dockyards. There were some men of outstanding ability who had proved themselves by their technical work to be capable of leading the application of technical science to the control of shipbuilding, but there was no external evidence in the rules, that much use was made of their capacity.

Heredity, environment and monopoly naturally caused extreme conservatism in action and produced the bureaucratic type of administration which should be strictly confined to Government Departments, where it cannot be helped. In spite of this handicap the rules had developed so far along old lines that they made provision for the construction of wood, composite, iron and steel ships. The rules for the construction of iron and steel ships were quite comprehensive and completely overshadowed the rules for periodical surveys; they were based on numerals which were approximately the sum of the breadth and twice the depth, multiplied by the length. The classification symbols were a development from those for wood ships, in which the figures 100, 90 and 80 replaced the smaller number of years previously used. I suppose the new numbers originated from a somewhat flamboyant suggestion that iron stood to wood as 100 does to 20 years, at least it was found necessary to explain that the symbols did not signify terms of years. The 90 and 80 symbols represented no more than a small reduction in thickness of shell in ships of comparatively small size, and affected nothing but an already excessive margin for wear and tear, a factor which varies from year to year in ships of every class. There were two other classes called "spar" and "awning" deck, which were intended to provide appropriate scantlings for flush-deck steamers, having greater freeboards than the least then usually adopted. The awning deck ship was one having full scantlings to the second deck and a light superstructure fore and aft; the spar deck ship was supposed to be intermediate in strength and freeboard between a full scantling flush-deck ship and an awning deck ship of the same gross dimensions.

It would require another paper to describe the inheritance of trouble which these inventions left to a succeeding generation of administrators, but it is sufficient to explain that the spar-deck type had usually more longitudinal strength than the rule of full scantlings. It is also unnecessary to dwell upon the rooted beliefs that weight was a measure of strength, irrespective of its disposition or upon the defects of a scantling system which made a multiple of a ship's dimensions a sufficient guide for the sizes of such things as rudder stocks, and which ignored conditions of support when giving sizes for beams, but I do wish to remind you that such things were indefensible, even from the technical standpoint of their time, and that the rules were framed primarily for the flush-deck vessels of the day. The flush-deck ship with large freeboard was then the most common type afloat, but in response to commercial demands the "spar deck" type had then been evolved. Experience had already proved that the reduction in freeboard for which they were designed, demanded better protection, and that spar deckers required forecastles and bridges to make them suitable for general service conditions. In view of subsequent developments it should be remembered that 280 ft. was a big cargo steamer in these days and that bridge houses were only coming into vogue. The well-deck steamers of the long quarter-deck type, which had been evolved to cheat numerals and secure good trim when loaded, had proved good sea boats at freeboards from the upper deck, which had previously been regarded as dangerously small. Although the full protective value of detached superstructures was by no means appreciated as yet, experience had by that time caused the completion of a cycle of development from flush-deck vessels having large freeboards, through gradual reductions in freeboard, to ships with relatively small freeboards but well protected by detached superstructures, which afforded high and dry navigating platforms.

Popular clamour, supported by the obvious advantage to underwriters of placing restrictions upon loading, had now caused the acceptance of a law to govern freeboards. This law was based upon freeboard tables prepared by Lloyd's Register, and it was an obvious thing to include that society in the administration of the law, although it was a breach of precedent. It was the first big step in the conversion of classification societies from private administration of control in one interest into recognised public authorities which retained private control; it also gave legal effect to the inextricable

association between draught and scantlings. As this great addition to the administrative control exercised by Lloyd's Register had no other counterbalance than Government control, owners who were independent of classification, some who kept aloof from it, and others who dreaded possibilities, united with the shipbuilders in Britain and determined, at the last moment, to set up another controlling body. They succeeded, and the British Corporation was appointed as an assigning authority under the Load Line Act, with the sympathy and support of the Government Department known as the Marine Department of the Board of Trade. The revised public attitude towards control is shown by the fact that the Committee of Management of the Corporation was required to have at least half of its membership composed of shipbuilders, engineers and underwriters, and the remainder were to represent shipowning interests. The effect of their entrance into freeboard work was immediate, because the committee was not hampered by an inherited angle of vision nor methods of administration; each case was considered purely on its merits and decided by analysis of structural facts, irrespective of classification labels such as "spar deck." Errors of administration which might have been perpetual were thus rectified before they had time to take root.

The subsequent history of freeboard work and legislation shows that the introduction into the Load Line Act, at the instance of the promoters of the British Corporation, of the words which oblige the Government to have regard to the views of the assigning bodies, procured a sort of "Magna Charta" for shipping interests, an invaluable association of the classification societies with Government control, which has spread and should spread still further. It has also made freeboard legislation an example of how laws can be and have been kept up to date.

The British Corporation rules were the first to apply established mechanical principles to the ordinary elements of ship construction, and were, therefore, approved by shipbuilders and condemned by reactionary minds as being the work of a shipbuilders' committee. The common criticism was of the "wait and see" order, founded on the belief that science is all very well but only experience really knows. In spite of its undoubted value as a restraint on rash adventure, it is unfortunate that "experience" is often nearly, if not quite, the most reactionary influence upon human progress. The committee was not a "shipbuilders'" committee, but one representative of all interests, composed of men who realised that shipowners were in need of a society which would devote itself to their best interests, to the technical and practical development of their ships, and to technical matters relating to them.

It is perhaps not understood, even to this day, why the underwriter is not the natural controller of the construction of merchant ships, although he was the creator of the system out of which control has grown. Let me put it thus: The best interests of a shipowner demand that he shall own the best possible ship that can be designed and built for his trade; that his ship shall be kept in such perfect order that no cargo is ever damaged through fault of the ship; that the shipbuilder's best interests demand constant devotion to the production of the shipowner's ideal and constant endeavour to keep pace with the shipowner's demands; when the shipowner and the shipbuilder have done their best, the underwriter's interests demand that he shall obtain the insurance of the result without paying any regard to classification, but that result is usually in the hands of owners who prefer to retain underwriting profits in the firm's account. Is not the interest of the shipowner the greatest of these three? It must not be forgotten, however, that the underwriter's interest is the origin of that high standard of honour and impartiality which distinguishes registry work; it demands absolute accuracy and honesty in its records, and his only reason for partiality is quality. On these business facts rests the whole modern system of control by committees which have no power but that of reputation. At the same time, it must be admitted that the underwriter's real interest is the actuarial value of the risk; it is reactionary because, temperamentally, he prefers a bad risk which he knows and can assess to one whose good qualities have yet to be expressed in averages.

The value of the new spirit of the British Corporation Committee has been constantly displayed, and is familiar to all students of the development of modern shipbuilding, but in view of the shortness of public memory, it may be recalled that in perfect sincerity and as a natural result of outlook and environment, such things as turret ships, large single-deck ships, Isherwood ships, and stringerless ships, were either condemned or failed to receive sanction until British Corporation approval had been confirmed by experience, or had at least been given to the design. By this new spirit the shipbuilder was treated as a friend in technical matters, encouraged to bring out new structural designs, and to depart from rules whenever and wherever the change was in the best interests of the shipowner. In fact, I can only recall one steamer as having been built strictly to the printed rules and tables of the corporation; every other has had some departure or modification to meet particular conditions. It has long been more common to receive outline plans from builders with requests for scantlings to meet specified conditions, than to get plans to check. This is surely more healthy than trying to squeeze the utmost out of numerals and understating scantlings in order to avoid involuntary excesses. The committee departed from convention in their system of classification, because they consider that if a ship is not made good enough to justify acceptance, no classification is possible; therefore, in their view, there can be no second or third class, because acceptance involves survey conditions which make the ship thoroughly fit for her service during the currency of class; every ship designed and accepted for sea service or for a special service is therefore classed as fit for that service, so that the principle holds good in application to all sorts of vessels.

It is, of course, impossible within the limits of a single paper to describe, in detail, the developments in classification work which have taken place during the past thirty years, but the most outstanding feature is the fact that about the middle of the period, Lloyd's and other societies modernised their rules for the purpose of bringing them more into line with those of the corporation. The technical and practical improvement was considerable, but, unfortunately, if I may dare to say so, they had not the courage to scrap the numeral systems. No matter how clever they may be, such systems must retain the defect of their quality of convenience; they can only be correct in spots, and as they can only take approximate measures of the actual factors in producing stress, the tabulated scantlings can only be approximately correct even at these spots. Above all, they ignore to an impossible extent, even for approximations, the direct effect upon scantlings of the most potent factor—the draught of the ship. The revision, however, did remove many glaring anomalies and brought the average standard of weight to the level which the British Corporation had established some twelve years earlier, as being consistent with increased strength. The ascending curve of British Corporation tonnage slowed down this period, probably as a grateful acknowledgment by shipowners of the fact that no classification now involved the penalty of carrying unnecessary steel as part freight, and in forgetfulness of past losses on that account. About the same period, as the result of departmental and other conferences, the Load Line Authorities agreed to apply experience of the value of superstructures and reduced the freeboards allowed for complete superstructures. This affected allowances for detached superstructures, so that in conjunction with other modifications, there was a general revision of freeboard assignments to the advantage of shipowners.

In 1913 a Load Line Committee was instructed to report upon the sufficiency or otherwise of the Load Line regulations in the light of twenty-five years' experience of their use and development. They reported, as you know, in terms which are a general confirmation of the existing regulations, but recommend obvious improvements in method and application as a basis for international discussion. They also propose standards of strength for the midship section of the hull and for the main frames. These are based upon an investigation of the rules of four classification societies, and have the effect of confirming the basic principles of the British Corporation stress standards. There seems to be an impression that the proposed standards are all minima of minima, but this is not the case. The evidence before me shows that the standard of longitudinal strength in way of deck openings is far from being a minimum of practice, as, except under the rules of the societies which work to the British Corporation tables, there are many cases which come below that standard.

During recent years the British Corporation have continued to develop their detailed requirements to meet experience, but left their tabulation unchanged, because they had adopted the practice of dealing with every case by means of direct calculation of stress, adhering to the original stress standards which were the basis of their first tabulation. In 1917, however, it was decided to publish the rules in a form which enables the builder in effect to make the direct calculations which used to be made for him. The designer is thus relieved from all trammels but those of efficiency, has the satisfaction of personal responsibility for making the best use of material, and the opportunity of making approval a certainty, by making accurate use of simple formulæ. As the vessel's draught is given its proper position as the predominant factor in scantlings, there is neither waste of material nor the use of approximations which permit variations of 2 ft. or 3 ft. in draught without change of scantlings.

Since the introduction of freeboard legislation introduced a new era of classification control, a generation has passed and the new one is nearly five years old. It may be taken for granted that so long as humanity is composed of mere men and women, history will retain its knack of repeating itself in other ways as it is at present doing in one respect. During the latter half of the past generation, the Government encouraged the construction of "shelter-deck" steamers, which was a new name for the old type flush decker with large freeboard but having freeboards a little greater even than the awning-deck standard. They were exceedingly good ships from the sea-going point of view, dry and comfortable, but when the closer estimate of the sea value of superstructures received effect in 1906, it was found that these ships of 400 ft. length and over were rather wet, and shipowners began to fit forecastles for protection. Commercial demands for deadweight, assisted by the absence of proper draught values from classification numerals, have again produced a type comparable with the old spar decker, which requires the protection of both bridge and forecastle. Thus the new generation is unnecessarily repeating the cycle which proved to the previous one that the three-island type is the best all-round ship.

The new leaven of thirty years ago has not yet leavened the whole lump, but the character of classification control has changed and improved to an extent which should prevent its return under any circumstances to that of control by one interest for one interest. In fact, the mere expansion of their powers of control makes it impossible for the societies ever again to become mere recorders of information. They are, or are becoming, great technical organisations from which shipowners and ship constructors expect advice, assistance and even originality, but not restrictions upon progress. This very advance, however, carries the penalty attached to all centralisation, the individual constructor may tend to lose his individuality and become a mere manufacturer, unless originality is encouraged by the society.

Most classification societies are now administrators of some form of legislation, and many are actually part of the State machinery for shipping control. Thanks to the catholic composition of most modern committees, the societies participate in the construction of almost all legislation which bears directly or indirectly upon ships or any part thereof, and no movement, public or private, is likely to take effect upon shipping, which does not carry the concurrence of the societies. It is fortunate also that the representation of the societies is regarded as essential to most of the standardising committees which are the modern craze and contain such reactionary potentialities.

It is only the corresponding growth of wider outlook which made possible that very recent conference between the British Board of Trade, Lloyd's, Bureau Veritas, and British Corporation, for the purpose of discussing proposals by a committee of marine engineers to standardise boiler construction rules. It is surely an intelligent deduction from the agreement which was reached at that conference that the world will soon work to a common standard which will permit a "Scotch type" marine boiler to be built and accepted in any part of the world by any Government or society. This standard is not reactionary, because differences have long been mere matters of opinion, design was as much ready for standardisation when mooted by me twenty years ago, as were the threads of screws, and no check is now proposed upon future individual improvement in design. With regard to classification symbols there are indications of a desire to move in the direction of the method adopted by the British Corporation, and perhaps in the coming generation it may be seen that there is no possibility of granting a class to a steel ship, which is not a guarantee of being fit for her work in every sense of the word.

At the present stage in evolution the most remarkable phenomenon is the great growth in the bulk of Lloyd's Register; already a very large society by virtue of age, past absorptions and widespread reputation as the well-beloved of London underwriters, a wonderful period of expansion began when their new rules were published about a dozen years ago; the war activities of Japan and America have also added largely to the volume of classed tonnage. Lloyd's register very rightly and very often claim the title of "premier" society by right of bulk, and evidently aim at further expansion through the development of a system of sub-committees in foreign countries. As already suggested, their Committee of Management is now a large and very influential body, which is thoroughly representative of every practical and technical interest in the control of the interests of the modern shipowners, but includes a large proportion of underwriters. The staff is now very large as a natural result of expansion, and, as always, includes men of proved technical ability of the highest order, but the world still awaits the inevitable issue of new rules.

Parallel with this remarkable expansion of one society, a system of international alliance between other classification societies has been developed within recent years. The Registro Navale Italiano, American Bureau, Imperial Japanese Corporation, and the British Corporation, are now united under bond of what they believe to be the best construction rules of the day, together with mutual availability of staff and interchange of technical views, while each retains autonomy of control.

Experience and observation teach me to think that owners do not always give sufficient thought to the real meaning of the phenomena of classification control or to their own real interest and share in their expression. It cannot, therefore, be too often and too much emphasised that the value of classification is that put upon it by shipowners; that without the support and goodwill of the owner no registry can continue to exist; that the society which best realises his best interests is the best society to support, and that no society can realise them to the full without his unselfish support and without the stimulus of seeking to merit it. They also teach me that classification societies sometimes act as if they did not know that their first duty is the maintenance of best interests of the owner; that these interests demand constant technical progress together with the maximum amount of practical knowledge and common sense in administration; that shipowners can provide their own classification and that the best owners sometimes feel that their interests are best served by themselves. It is obvious that the last is an unsound economic position, because classification survey must always be less costly and should be more valuable than private inspection—its very cheapness sometimes tells against appreciation of its true value. It is equally obvious that common withdrawal from class, such as happened in the past, indicates that shipowners and their colleagues on the classification committees have failed in their duty to the organisation of their society. It follows, therefore, that the success of classification depends upon the living interest of shipowners in impersonal duties, even more than upon showing their confidence in themselves by placing the care of their ships in the hands of the societies they control.

Japan is now preparing the external form of the body to contain the spirit which has brought her into the international alliance of classification societies, and I shall be more than gratified if any sentence in this most imperfect estimate of the nature and position of classification control should be found to have a useful meaning or should have helped to show how completely every shipping interest is covered by the best interests of the shipowner, and how thoroughly these interests require the best possible expression of progressive, practical and technical naval architecture from the control and organisation of a modern classification society.

50-TON STEEL GENERAL SERVICE CAR.

CONSTRUCTED BY THE PRESSED STEEL CAR COMPANY, PITTSBURG, PA., U.S.A.

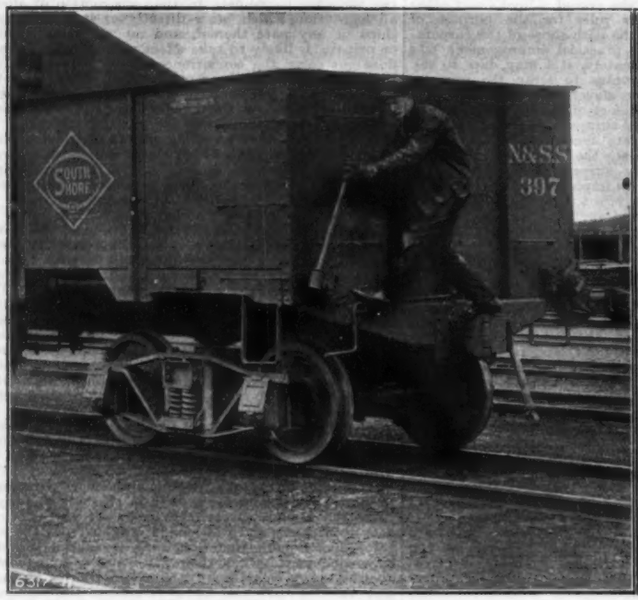


FIG. 7.

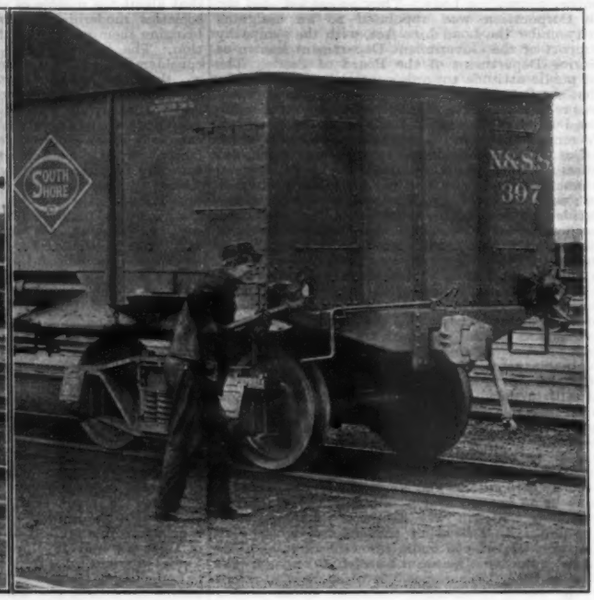


FIG. 8.

DURING the war the Pressed Steel Car Company, of Pittsburg, Pa., U.S.A., whose London offices are 26, Victoria-street, Westminster, built 5,000 general service cars of 50 tons capacity for the Russian Government, as well as a larger number of similar cars for France. Cars of a very similar type have also been supplied to a number of American railroads. These cars embody several interesting features, as will be seen from our illustrations, Figs. 1 to 6, on Plate LXVI, and Figs. 7 to 16 on the present page and pages 605 and 608. These cars have hopper doors for side dumping, and general drawings of the Russian pattern are given in Figs. 1 to 6, Plate LXVI, while Fig. 14, page 608, is a view showing the car with the hopper doors closed, and Fig. 15 with them open. The cars of this contract were also provided with removable end doors. Fig. 16, page 608, which is a view looking down into the car with the hopper doors open, shows the wooden end doors, while the other view, Fig. 15, shows one end removed and dropped down inside the body when it is required to accommodate long loads.

From the general drawings given in Figs. 1 to 6, Plate LXVI, it will be seen that the car is composed almost completely of pressed sections. The main frame consists of two longitudinals running from headstock to headstock, together forming an inverted trough, 1 ft. 9 in. deep, as seen in the cross-section, Fig. 5. The longitudinals are made of $\frac{7}{16}$-in. plate pressed to shape, each side being joined at the top to a centre 4-in. by 4-in. tee, and reinforced at its lower edge by a 4-in. by 4-in. angle iron. The body bolsters are built integral with the frame, each consisting of two steel pressings strengthened with angle irons (see Fig. 11). A malleable casting acts as a centre brace between the longitudinals. The whole is stiffened on the upper side with a 10-in. by $\frac{1}{4}$-in. plate extending right out to the sides of the car (Fig. 11), and on the underside by a $\frac{5}{16}$-in. plate, 22 in. wide, extending out to just beyond the side bearings. The bogie centre castings are of steel. The side bearings are of $\frac{3}{8}$-in. pressed steel, and may be seen in Fig. 11.

A section of the car showing the centre cross bearer is given in Fig. 4, this part being shown to a larger scale in Fig. 10. This cross bearer is made up of $\frac{1}{4}$-in. steel pressings and rolled angles. It is $16\frac{1}{2}$ in. deep at the centre and 9 in. deep at the sides. At the top it is stiffened by a 9-in. by $\frac{1}{4}$-in. cover strip, and at the bottom by a 6-in. by $\frac{5}{8}$-in. steel plate. The intermediate cross bearers, four in number, are of $\frac{1}{4}$-in. plate and angles. At all these points the longitudinals are braced together by a pressed plate of $\frac{1}{4}$-in. steel. The headstocks are of $\frac{3}{8}$-in. pressed steel, reinforced at the top with a flange and angle, at the bottom with a flange, and with the draw-bar casting. Buffing shocks are resisted by pressed steel channels and diagonal bracing, as may be seen in Fig. 2.

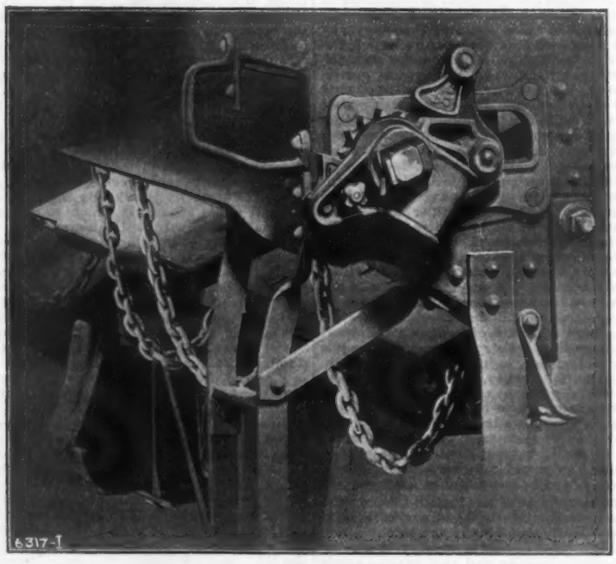


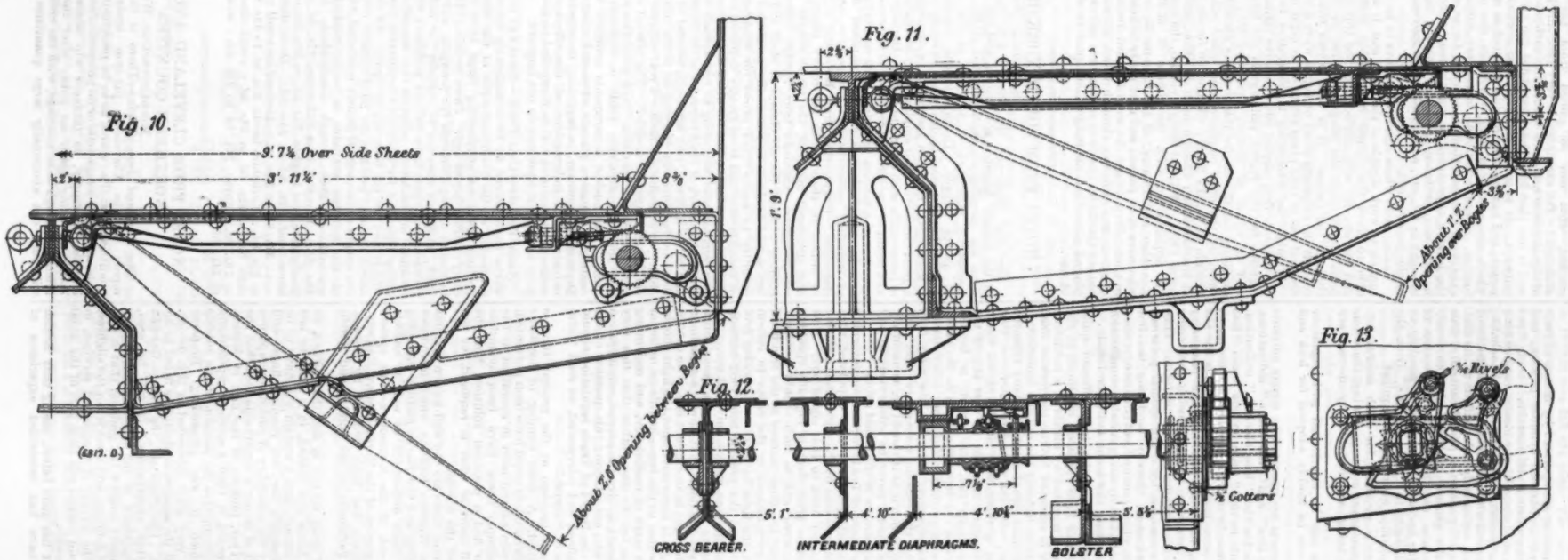
FIG. 9.

Sole bars are not used, but the headstock is further stiffened by a short length of sole-bar extending between the headstock and the body bolster. This is a pressed steel shape, $\frac{5}{8}$ in. thick, and is clearly seen in the views reproduced from photographs. The side pillars are made of pressings of $\frac{1}{4}$-in. steel riveted to the cross-bearer ends. The side plating is $\frac{1}{4}$ in. thick with a coping of 4-in. by $3\frac{1}{2}$-in. by $\frac{5}{8}$-in. bulb angle, and is sloped and flanged to give the hopper-shaped bottom to the car. The end doors are of $2\frac{1}{2}$-in. yellow pine, with $2\frac{1}{2}$-in. by $2\frac{1}{2}$-in. by $\frac{1}{4}$-in. angle all round. They have two hinge straps, and as already stated drop inwards. They are held in place when in use, by latches shown in Fig. 16. The hopper doors are 16 in number. They are of $\frac{1}{4}$-in. pressed steel reinforced by flanges, Z-bars and angles, each door being hung by three steel hinges to malleable iron butts on the longitudinals.

The car will clear over 99 per cent. of the load. The majority of the doors drop 24 in., but those over the bogies have a drop of about 14 in. The drop is sudden, and the jerk of the doors on the stops gives the material a good start in the discharge. The door-operating gear is a creeping shaft device which relieves the lifting chains of all load when the doors are closed, while the stops similarly relieve them of any strain on the doors being opened. The chains are only used for closing the doors. The 16 doors are operated by four shafts, each worked from one corner of the car. Details of this arrangement are given in Figs. 10 to 13, while Fig. 9 shows a view of the ratchet gear. The operation of this gear will be clear from these illustrations. The end of the shaft is carried in a slot, and the ratchet gear enables the shaft to be rotated and the chains wound up on the worm castings, and, when the doors have been fully raised, if the winding operation is continued the shaft is drawn under them, moving inwards in the slots in the cross bearers, &c., the toothed pinions shown in Figs. 10 and 11, engaging in curved racks on the under side of the doors. A lock

50-TON STEEL GENERAL SERVICE CAR.

CONSTRUCTED BY THE PRESSED STEEL CAR COMPANY, PITTSBURG, PA., U.S.A.



is provided for the ratchet pawl which can be thrown up to release the doors. The doors are thus wedged well up, and are supported by the shaft. Figs. 7 and 8 show the doors being operated on a very similar car. From these views it will be seen that this work may be performed either from the car itself, or from the ground. A stout staff is used as a lever, and this may be fixed in the ratchet socket in the most convenient manner, according to the position of the operator. Fig. 8 shows the doors open and the ratchet gear in one place in the slot. Fig. 7 shows the doors closed, and the ratchet gear drawn in to the other limit of the slot. All the doors of a car can be closed in about 2 minutes by one man.

The following are some general dimensions of these cars. The length of body is 40 ft. inside; width inside 9 ft. 6¾ in. The depth of the car body is 4 ft. 4 in. The distance from centre to centre of bogies is 29 ft. 7 in. The drop doors are 4 ft. 4 in. long, except for those over the bogies, which are 4 ft. 1¼ in. long. The cars were equipped with Russian Westinghouse brakes, with 10-in. single piston cylinder, braking being on all wheels, and with a hand brake worked from a hand wheel standing above the end. The Russian standard buffers were fitted, and draw-hooks with screw coupling. The bogies were of the arch-bar type of 6 ft. 3 in. wheel base. The wheels were Schoen rolled steel, 41$\frac{15}{16}$ in. in diameter, pressed on to the axles at between 55 tons and 75 tons (metric). The journals were 5½ in. by 10 in. The bogie bolsters are of pressed steel with cast steel centres.

SOME ASPECTS OF ENGLISH AND FRENCH RAILWAY SIGNALLING.*

By Lionel Hiller, A.M.I.Mech.E.

The subject of railway signalling is one of the interesting and not the least of the sciences that have been evolved to aid and make safe fast railway travel. The history of signalling is wrapped up in the romance of railways, as without it it is doubtful whether the perfection arrived at to-day when one consults a "Bradshaw" would ever have been achieved.

A very interesting phase of signalling is that played in the recent Great War, in which were displayed divergent ideas by engineers of the different allied countries. During hostilities the British War Office and Ministry of Munitions had to arrange to supply materials and assist in working the French Railways that operated within the war zone. There was here, therefore, a great test in the trial of all classes of railway materials: especially in signalling, as British officials and drivers had to work to French methods obtaining at the various points of operation.

Coming back, however, to the rudimentary principles underlying railway signalling, it might prove interesting to state briefly the general means employed in piloting railway traffic through from point to point, both on single and double lines of railway, explaining the English and then the French systems of carrying them out. In British practice, the signalling usually consists of the outlying distant signal, and the home signals; in some cases outer home signals are provided, in order that a train may be brought further into the section in case of necessity, but some companies do not like this practice—it being purely a case of local traffic conditions. Sometimes starting signals are provided at junctions and also advance signals; but these are not vitally essential—the starting signals being, of course, necessary when trains are leaving a station.

The practice in England is to free the distant signal by the whole of the main line stop signals for which the distant applies, and, therefore, the distant signal cannot be pulled off until the road is absolutely clear throughout the section. The French method is, however, different. The first signal a driver approaches is a fixed visual signal consisting of a post carrying a semi-transparent sheet of glass with the lettering "Bifur" (abbreviation for bifurcation) in black. At night the face is illuminated from behind, and presents the same aspect as by day. It is provided on roads approaching a junction, one in the facing direction, and one for each trailing direction, and usually fixed 200 metres in rear of the distant signal.

When approaching a swing bridge in France the same signal is used, except that the lettering is different. Approaching a lift bridge, the words "Pont Levant" are indicated, and when approaching a swing bridge, the lettering is "Pont Tournant." This type of signal is also used should a train be entering a dead-end siding (cul de sac) the lettering being "Voie en Impasse." There is also an indicator fixed at the stop block in a similar manner, lettered "Heurtoir de l'Impasse." The Voie en Impasse signal can also be a moving signal, or can be used in conjunction with an absolute stop signal.

The distant signal, known as the "Disque à Distance," consists of a red painted disc with a white border facing the driver, and shows as a warning signal when at right angles to the track. In the clear position it is effaced, that is, turned parallel to the track. At night, this signal consists of a single red light, which shows through a round aperture on the right-hand side of the disc, and the clear signal is a white light. The signal normally is at "clear," and is only held at "danger" to cover the passage of a train through the section, shunting operations, or other obstructions on the line. Usually there is no interlocking between the distant signal lever and the square stop signal described later. The signal post is rendered more visible by painting the front and sides towards the track, red and white, in alternating horizontal bands, 50 cm. deep. Usually the "Disque à Distance" is fixed 1,200 m. in the rear of the square stop signal, except on a falling gradient, say, of 1 mm. per metre or more, when the distance may be increased to 1,300 m.

The next signal encountered is a green and white chessboard indicator known as "Indicateur damier vert et blanc." This signal indicates to a driver his approach to a square stop signal, and may repeat the position of the stop signal; that is, whether it is at "clear" or at "stop," by being coupled up to the same working lever or levers, or the target may be a fixture. The face of this signal is divided into four equal squares. The upper left-hand square and the lower right-hand square are green; the other two are white. The squares are of glass, and at night the whole face is illuminated from behind, thus showing the same indication as by day. During the war, however, these signals have been provided with wooden faces on poles, and the night indication is given by a green light in the centre of each green square. It is fixed 800 m. in rear of the stop signal (or 900 m. if the gradient is falling 1 mm. per metre or more).

The next signal *en route* is the absolute stop signal

* Abridgement of paper read before "The Railway Club," September 10, 1920.

("Signal carré d'arrêt absolu"). The face of this signal is square in form and divided into four equal squares with a border along each edge. The upper right and lower left-hand squares are red and the borders here are white. The upper left and lower right-hand squares are white and the borders at these parts red. At "stop" it stands at right angles to the track and shows at night two red lights through round apertures near the sides of the square on the horizontal centre line. At "clear" it stands parallel with the track and shows at night a single white light. Only one lamp is used, and the second red light in the "stop" position is obtained by means of a reflector.

The operator of the signal at night is shown a white light if the signal is at "stop," and a blue light if the signal is "clear." This signal is used as a protection signal at facing points, converging roads, railway crossings on a grade, lift bridges, &c., and is applied as a system independent of block working. A detonating appliance is usually provided with a stop signal, the detonator or fog signal, being on the rail when the signal is at "stop," and withdrawn when the signal is at "clear."

The above are the usual signals in ordinary running, but other signals are brought into use for the cases specified hereunder.

A caution signal (Disque de ralentissement) is fixed where it is necessary to warn a driver to reduce speed on account of facing points, curves, &c., to 15 km. per hour. In construction this signal is identical with the distant signal, but the face of the signal is painted green with a white border. At "caution" it is at right angles to the track, and shows a green light by night. At "clear" it is parallel with the track, and shows a white light to the engine driver. This signal may also be used in place of the Indicateur de Direction, next described.

Point direction indicator (Indicateur de Direction) consists of three types, two of which are very similar in application and reading. The principle of these two is the displaying of a fishtail arm on that side of the supporting post which corresponds with the direction towards which the points are closed, and the obscuring of the arm on the side towards which the points are open. At night a purple light is displayed on the side where the arm would show by day, and a white light on the side where the arm is blinded.

The third type, which shows fishtail arms set one above the other, to the left of the supporting post, is better applicable to junctions with a multiple of directions, as arms can be provided for each direction; the top arm reading to the direction on the extreme left, the second from the top to the second from the left, and so on.

For the direction that is open the arm shows at 45 deg. below the horizontal, and at night a white light is shown. A purple light at night instead of the arms shows for the closed roads. The arms are painted purple with white border. These indicators are operated by rigid connections to the point switches, and are fixed opposite the point ends in the case of a single junction, or opposite the ends of the leading point in the case of two or more junctions.

There are also two dwarf types of point indicator. In each of these the arm, of double fishtail pattern, painted green, shows horizontally at right angles to the track for a subsidiary direction (at night this indication is given by a green light) and is turned parallel to the track; that is, effaced for the driver for the main direction. The main direction indication at night is a white light.

There is another signal that is known as the limit of protection (Limite de protection) which consists of a post bearing these words: "800 metres du disque." This is not a driver's signal, but is fixed 800 m. in advance of a distant signal, which is understood to give sufficient protection to a train beyond that distance. A guard of a train when brought to a standstill at some point in rear of this limit of protection would not, therefore, be required to go back to protect his train by detonators or hand signals. The distance of 800 m. is subject to an increase of 100 m. if the gradient is falling 1 mm. per metre or more.

Electrical signalling has not been touched upon in this paper, as the author does not wish to complicate the account of the general method of signalling just described. The installing of lock and block has marked a great advance in signalling refinements, but owing to its rather expensive character it has not been generally adopted in the United Kingdom, although a very great deal has been put in on the South African Government Railways. This system is such that unless permission has been sought for, and obtained, on the block instrument, the signal and point levers in that cabin cannot be pulled until they are electrically released by the block instrument, thereby ensuring with absolute certainty that the line ahead is clear, or otherwise, for the train to proceed. In the author's opinion, lock and block is very desirable for the protection of rail traffic approaching swing bridges, and possibly very busy level crossings.

With regard to double line block instruments, Messrs. Tyer and Co., Limited, who have for many years manufactured a one-wire, three-indication type of block instrument, have recently introduced a new block instrument of a similar nature, but with additional features which will allow great facilities for regulating train traffic, and which should prove a great boon to the operating departments of railways.

Some of the special features of this instrument are as follow:—

Interlocking of commutator with the plunger. This is so arranged that when the commutator is turned from any one position to another no further movement can take place until the plunger is pressed home and the signal recorded, when the commutator is again free. These turning movements are in either direction and all signalling operations are easily manipulated with one hand.

The indicating needles are operated by means of twin armatures of Tyer's well-known cylinder pattern, and the entire needle movement is self-contained, being fixed to the ends of the steel cores of the electro-magnetising combination by four screws, thus being easily detachable. The dial can be removed without effecting the adjustment of the needles, which are entirely independent of the dial.

The "line blocked" position is placed centrally, thus conforming with the general practice. As previously stated, the indications can be given irrespective of sequence; thus, for instance, rendering it possible to place the needle directly to "train on line" from the "line blocked" position, when this is required.

Only one battery is required for each instrument, and there are no permanent currents flowing, the whole of the signalling being accomplished by momentary currents.

The instruments can be interlocked with signal or point levers, and can be readily adapted for lock and block working.

As these instruments are operated by strong currents for the "train on line" and "line clear" indications, and weak currents for the "line blocked" indication, and the line currents in the "train on line" and "line clear" positions directly operate the needle movement, it is necessary to have low-resistance windings for the needle movements, and this precludes the possibility of switching out stations without using balancing resistances to keep the working currents uniform. This, however, can be overcome by using special polarised relays of high resistance, thereby rendering the line resistance negligible, which join up local circuits operating the needle movements, and by using suitable commutator connections for operating the home indicator locally.

A great improvement has also been effected quite recently in the form of light repeater, inasmuch as the light itself is actually repeated by means of a miniature electric bulb which is actuated by the thermostat fixed on the oil or gas lamp, lighting the outside semaphore; or an electrically-lighted signal can be visually repeated in a similar manner, with the difference, however, that instead of utilising a thermostat at the signal itself, a special relay is brought into use, so that should the outside semaphore lamp fail, the circuit is broken through the relay, and the repeating lamp in the cabin is automatically extinguished. On the other hand, however, should the repeating lamp fail, the relay only will be affected, and the outside semaphore light will still remain burning, which is as it should be, as naturally the outside fittings should never be subservient to any form of repeating apparatus in the signal cabin.

According to the Board of Trade regulations governing railways in the United Kingdom, it is stipulated that any signal that cannot be seen by the signalman operating same must be repeated back to that signal-box. Now the light which burns after dark is logically speaking the arm's representative, and as such should certainly be treated in exactly the same manner as the arm itself by being electrically indicated in the cabin to inform the signalman that the light is, or is not, burning properly; especially, as at the present time long-burning signal lamps are coming into almost universal use.

Now a long-burning lamp will, in some cases, burn continuously for over 200 hours, but how is a signalman to know whether the light is an efficient one, if he cannot see it? Therefore, it is imperative that the light should be electrically repeated to the box—half-flame or under being taken as the mark of inefficiency, and registering "light out." It is felt by the author that this very important point should receive the earnest consideration of the authorities who are studying this question at the present time, and the Board of Trade regulation should be more clearly defined and interpreted, to read "arm and light" in place of "signal."

Another important problem at the present time is that of train control. A great number of accidents have occurred which certainly could have been prevented, had a system of train control been in operation at the scene of the mishap. There have been countless attempts made to find a practical solution, but the majority either fall short of what is required, or are commercially out of the market.

At the present time, there are the well-known systems in use on the Great Western Railway which introduces audible cab signalling, and the Raven audible signalling which introduces route indications as well as audible signalling in the cab of the locomotive—this system being in use on a portion of the North-Eastern Railway. Another good system has been evolved by Messrs. Cortez-Leigh and Parkinson, of the London and North-Western Railway.

The problem of train control is one that affects all railways, both at home and abroad, in a more or less degree, and at no distant date a system will have to be decided upon—especially for fast running lines—and installed to prevent the possibility of outside semaphores being over-run. It is rather a remarkable fact that the late Mr. Edward Tyer, founder of the firm of Messrs. Tyer and Co., invented in 1869, a repeater reproducing electrically on the locomotive the position of the outside semaphore to which it was proceeding. Emperor Napoleon III was very much interested in this device, and he desired that the apparatus should be fitted to his own special saloon. Unfortunately, the Franco-German War stopped further experiments. It will be seen, therefore, that practically at the inception of railway signalling, the pioneers foresaw the problem that is still awaiting a practical solution, and there is not the slightest doubt that, with the advent of accelerated services, in the near future, train control will form part of the usual signalling arrangements.

Reiterating what has gone before, seeing that British railway officials have had intensified experience of French railway methods and apparatus during the recent conflict, what can be gained from the knowledge obtained? For example: A very excellent French type of signal motor has come within the author's experience, and is one that is in most extensive use on the French railways. It is small, compact, and worked with little power, and can be very readily adapted to work signals which are situate a long way from the cabin; and further, where additional levers are required in an existing frame, and there is no room for an extension of the locking apparatus, the signals can be motor-worked by utilising switches, and the existing signal levers brought in for, say, additional switch movements, which might be required.

Taking cases where signal wires have to be run through tunnels to work signals at the other end, it is far preferable to have the signals in question motor-operated and the electric wire carried over the top on the same poles which carry the telegraph wires, or run in cable through the tunnel. It is well known that in certain tunnels the sulphuric effect on signal wires is so great that renewal has to take place every six or eight months.

It might be interesting in conclusion to state that the author's firm carried out extensive signalling manufactures for the French railways in the late war zone, and on behalf of Messrs. Tyer and Co., the author expresses his thanks for the courtesy extended towards them by the chief engineers and other officials of the Chemin de fer du Nord; Chemin de fer de Paris, Lyon et Mediterranée; Chemin de fer de l'Etat, and Chemin de fer de l'Est. Without being invidious, the author couples his appreciation with the names of M.M. Aumont, Candelier and Dautry, of the Chemin de fer du Nord, who were most patient and ever ready to bear with them in their efforts to get the work forward during the times of stress and difficulty through which all went, and the author thinks he is safe in saying that railway signalling played more than an insignificant part in all the zones of war.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—At the time of writing, the result of the miners' ballot is not known, and the majority of firms are carrying on with depleted staffs. Output is necessarily restricted as a result of the curtailment of power supply. Unemployment throughout the engineering and steel trades is not seriously greater than a week ago. Firms in general have managed to retain a great number of their employees by instituting a system of fewer shifts with alternate staffs. Damage to industry as a result of the strike is reported to approximate three-quarters of a million pounds. This covers loss in wages and in output, but is chiefly composed of the value of cancelled contracts and prospective orders placed elsewhere. Engineering firms have still a fair volume of orders on their books for heavy plant, machinery and structural material, the latter largely for railway requirements. Inquiries from foreign buyers are still coming to hand for all classes of steel and machinery, but actual business is practically precluded by general inability to quote fixed prices for contracts. Output of crucible steel has been greatly depleted owing to the necessity to conserve fuel for other departments. Manufacturers are also beginning to feel acutely the effect of the closing-down of blast furnaces in the South Yorkshire and other districts, and although several of the largest firms are patriotically carrying on to the utmost of their ability, it is doubtful whether a real collapse of industry can much longer be avoided. The special steel section presents few new features. New purchases are at a very low ebb. Consequently trade in expensive alloys is quiet. The busiest departments continue to be those dealing in spanners, pincers, saws and other small tools. Depression, however, is beginning to appear in the file industry, and independent of the effect of the coal strike manufacturers will be compelled to institute short time working if bookings do not improve.

South Yorkshire Coal Trade.—Stocks at iron and steel works have proved to be considerably larger than was estimated at the commencement of the strike, and by pooling resources engineering firms have managed to carry on from day to day. There remain at the collieries, in excess of requirements for pumping and ventilating work, sufficient reserves to transfer for industrial use. Reserves at depots have proved sufficient for the maintenance of skeleton supplies to householders. The dump organised by Sheffield Corporation for emergency supply has not yet been drawn upon. An exceptionally active demand prevails for blast-furnace coke now that the output at furnaces is greatly restricted, but the whole of the tonnage available is under control. Nominal quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little new to report of the Cleveland pig-iron trade. Foundry qualities are still so scarce as to be practically unobtainable, and there seems little or no prospect of early material increase of supply, as furnaces will necessarily work badly on being again set going after their enforced idleness through coke shortage, with the result that they will turn out abnormally large quantities of inferior

iron of which there is already a very ample supply. Sellers are freely offering from stock forge, mottled and white descriptions, at 225*s.* for home consumption. For export, 247*s.* 6*d.* is asked for forge, but a good deal less would doubtless be accepted; and mottled and white are on sale at 230*s.* for shipment abroad.

Hematite.—Hematite keeps steady and firm. There is not a great deal available for disposal, but a few sales are reported, and some firms are stated to be rather keen to secure orders. Though drop in values is hardly looked for at present, it seems significant that makers are keen to enter into forward contracts at current rates. Nos. 1, 2 and 3 East Coast brands are 260*s.* for home purposes and 265*s.* for shipment to France, Belgium and Italy; whilst for export elsewhere up to 280*s.* is asked.

Manufactured Iron and Steel.—There is very little passing in finished iron and steel just now. Prices are not quotably altered, but in several branches marked downward tendency is noticeable. Works are still closed through failure of the fuel supply, but some firms hope to restart a week hence. Manufacturers have stocks of certain materials, and from these they are open to sell, but customers are not easily found. Reported further success of foreign competitors in home and foreign markets is causing much apprehension. The following are among the principal market quotations:—Common iron bars, 30*l.*; marked bars, 32*l.*; iron angles, 30*l.* 15*s.*; steel bars, 24*l.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; heavy sections of steel rails, 25*l.*; fish plates, 30*l.*; and corrugated galvanised sheets, 38*l.*

Shipments of Iron and Steel.—The exports of iron and steel from Middlesbrough for the month of October are officially given at 55,244 tons, comprising 26,235 tons of pig-iron, 1,909 tons of manufactured iron, and 27,100 tons of steel. Of the pig-iron loaded, 13,226 tons went to coastwise customers and 13,009 tons went abroad; of the manufactured iron shipped, 20 tons went coastwise and 1,889 tons went abroad; and of the steel cleared, 1,520 tons went coastwise and 25,580 tons went abroad. Scotland was the best customer for pig-iron, taking 8,456 tons; whilst Belgium received 7,671 tons; France, 2,024 tons; Germany, 940 tons; and Italy, 500 tons. India was again the largest purchaser of both manufactured iron and steel, importing 841 tons of the former, and 9,960 tons of the latter. Of the other principal customers for steel, Russia took 2,146 tons; and Japan, Finland, China, British West Africa, the Argentine, and the Straits Settlements, each imported over 1,000 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—Unemployment is becoming more and more pronounced throughout the country, and another week or so must elapse before any improvement can take place, even although the miners decide to accept the offer and return to work next week. Stocks of fuel have run out and many more establishments will be under the necessity to completely close down by the end of this week. Business has fallen away to an alarming extent, and in this area alone there is an absence of demand for almost any kind of material, the like of which has not been experienced for a number of years. There is plenty of work to give out, but buyers are still holding back because of the high prices demanded all round, and unless there is a considerable easing off in the near future some of the contracts are likely to go to foreign makers, who are already sending in fair lots of iron and steel material. Export business is completely off for the present.

Scotch Steel and Iron Trades.—No change has taken place in the iron and steel trades of the West of Scotland during the past week, beyond the natural expectation that many more of the hands have been suspended temporarily. The quantity of fuel available was nothing like sufficient to run the majority of these works beyond a few days, and so the production of plates, &c., has practically ceased. When a resumption takes place the orders already booked will take up the output for a month or two, but beyond that the outlook is fairly blank. During recent months buyers have not been giving out orders with any freedom, and prices will have to come down considerably from their present high levels before they can place contracts. Inquiries from abroad for manufactured iron and steel have not been very numerous of late and until the coal strike is over and business more settled again the prospects of our foreign trade opening out are rather remote.

Scotch Shipbuilding.—The poor shipbuilding returns for the past month reflect the unsettled state of the country and the difficulty experienced in obtaining the necessary material to maintain output. The following are the figures for the different Scotch districts for the past month, and also those for the year to date:—

	October, 1920.		Ten Months, 1920.	
	Vessels.	Tons.	Vessels.	Tons.
The Clyde	13	27,616	179	517,041
The Forth	2	4,320	28	44,558
The Tay	1	815	7	12,718
The Dee and Moray Firth	3	2,170	38	10,829
	19	34,921	252	585,146

The Clyde output for the month of October is the second lowest monthly total for the year and is much below the average, while it is also the poorest October return since the year 1910. The total for the year to date is nearly 63,000 tons above the figure for the corresponding period of last year, but it only ranks third in recent years, as in 1912 the total was 520,318 tons, and in 1913 it was 559,834 tons. The prospects of this year supplying a new record tonnage are fast fading away, as about 240,000 tons—now required to exceed the 1913 record total—during the remaining two months of this year is just rather more than can be expected from the yards. It is anticipated, however, that last year's figures will be bettered, and to do this the new tonnage during November and December will require to be about 130,000 tons. Work in the yards is plentiful, but supplies of fuel and general material are extremely scarce and difficult to secure.

Scotch Pig-Iron Trade.—Now that the furnaces have mostly been damped down owing to the miners' strike there is practically nothing doing in the pig-iron trade of Scotland. Buyers are not operating and sellers have little to offer. Prices mentioned as the current values show no change, but easier quotations are being looked for in the near future by buyers, who had expected a reduction for this month.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The past week was again an idle one as far as the coal trade was concerned. The continuance of the strike of colliery workers and the uncertainty as to whether the Government's proposals would be ratified by the men caused operators to hold off pending definite news. In fact, even had the prospects for the acceptance of the Government offer been more favourable, it is doubtful if much business could have taken place, for the position in regard to export releases was also undecided. The results of the ballot so far as they were known to-day created a feeling of disappointment and further increased the doubts of operators as to whether there would be a resumption of work on Monday. In fact, as far as South Wales was concerned, it was thought not improbable that, even should the final figures be in favour of acceptance, the men might refuse to return to work, for the local ballot has shown a majority of nearly 2 to 1 against the acceptance of the Government terms. The effects of the strike have been very serious in South Wales, as will be realised from the fact that foreign coal shipments in October amounted to only 779,800 tons, compared with 971,300 tons in the preceding month. Of the October shipments 480,200 tons went to France, 105,600 tons to Italy, 26,000 tons to South America, 41,000 tons to Spain, 21,000 tons to Portugal, 5,000 tons to Greece, 68,700 tons to British coaling stations, and 32,300 tons to other countries. Shipments in the past week were the smallest for any similar period this year, for they only amounted to 61,400 tons, compared with 139,900 tons and 279,400 tons in the two respective preceding weeks. The effect of the strike on shipping is also obvious from the fact that in October 110 vessels cleared foreign from South Wales ports with empty holds, owing to their inability to obtain cargoes, while in the ten months ended October ballast clearances totalled 1,146, compared with 486 and 375 respectively in the corresponding period of 1919 and 1913.

The Iron and Steel Trades.—At a joint meeting of the Siemen's Steel Association, held at Swansea yesterday, the demand of the day or maintenance men for an increase of 25 per cent. in wages was considered. The employers stated that the position of the trade did not warrant the increase asked for, also that there was no reason for the steel trade following the tin-plate trade in respect of such advance. The employers were prepared to allow the craftsmen to accept the sliding scale or the district rate of wages, also that the matter might go to arbitration if the men agreed.

SCIENTIFIC AND INDUSTRIAL RESEARCH.—The Secretary of the Department of Scientific and Industrial Research anounces that a licence, under Section 20 of the Companies' (Consolidation) Act, 1908, has been issued by the Board of Trade to the British Motor Cycle and Cycle Car Reasearch Association, which has been approved by the Department as complying with the conditions laid down in the Government scheme for the encouragement of industrial research. The association may be approached through Major H. R. Watling, "The Towers," Warwick-road, Coventry.

THE BRISTOL SEAPLANE.—In order to supply the demand which it is anticipated will be made in the near future for seaplanes, especially in the newer countries where additional means of communication between ports or along the great waterways are desirable, the Bristol Aeroplane Company, Ltd., Filton House, Bristol, have recently placed upon the market a machine known as the Bristol seaplane. In its main features the new machine follows the lines of the well-known Bristol fighter, but two main floats 19 ft. 6 in. in length have been added. The floats are Vee-bottomed, and each is divided into six water-tight compartments. They are designed so as to be easily detachable, and can be removed or replaced without interfering with the bracing wires. For stowing and overhauling the machine can rest on the chassis. A walking way is provided along the whole length of the floats and water rudders and attachments for towing lines are also fitted. We understand that, in actual use, the machine has proved eminently satisfactory both on the sea and in the air. Carrying a full load, three persons, the machine is stated to have taken off from the water after a run of under 400 yards on a practically calm day, and also to have given a good performance with a heavy swell running.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, November 5, at 6 p.m., meeting at the Institution, Storey's Gate, Westminster. The Thomas Hawksley Lecture will be delivered by Sir Richard T. Glazebrook, K.C.B., Sc.D., F.R.S. Subject: "Limit Gauging."

THE SURVEYORS' INSTITUTION.—Monday, November 8, when the president, Mr. John Wilmot, will deliver an Opening Address. The chair will be taken at 8 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS—GRADUATE SECTION.—Monday, November 8, at 7 p.m., Meeting at the Institution, Storey's Gate. Paper: "Electric and Hydraulic Elevators," by Mr. C. Poole, Graduate, of London. Chairman, Dr. H. S. Hele-Shaw, F.R.S., Member of Council. [Students of the Institution of Civil Engineers and of the Institution of Electrical Engineers are invited.]

THE INSTITUTE OF INDUSTRIAL ADMINISTRATION.—Tuesday, November 9, at 7 p.m., Ordinary Meeting in the Conference Hall, Central Hall, Westminster. A paper will be read on "The Influence of Exposed Records on Output," by Mr. F. M. Lawson, consulting engineer (illustrated by lantern slides). Chairman, Mr. H. Mensforth, C.B.E., M.Sc., Director-General of Factories, War Office.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, November 11, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Inaugural Address by Mr. L. B. Atkinson, President, and presentation of premiums.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, November 12, at 8 p.m., at Caxton Hall, Lecturette, "Hydraulic Sand Packing of Colliery Workings in India," by Mr. R. H. Squire, Member.

THE SWEDISH FOREIGN TRADE.—We read in *Swedish Export* that according to the calculations and estimates made by the statistical department of the Skandinaviska Kredit Aktiebolaget, the Swedish foreign trade has developed very favourably during the last few months. It is in particular wood goods, paper and wood pulp that have helped to swell the export figures.

PERSONAL.—The name of the company, Dobbie McInnes, Limited, manufacturers of engineering and nautical instruments, 57, Bothwell-street, Glasgow, has been changed to Dobbie McInnes and Clyde, Limited, the alteration involving no change otherwise in the constitution or in the management of the business.—The businesses of Allen-Liversidge Limited, Imperial Light Limited, and the Dissolved Acetylene Company, Limited, have been amalgamated under the name of Allen-Liversidge, Limited.

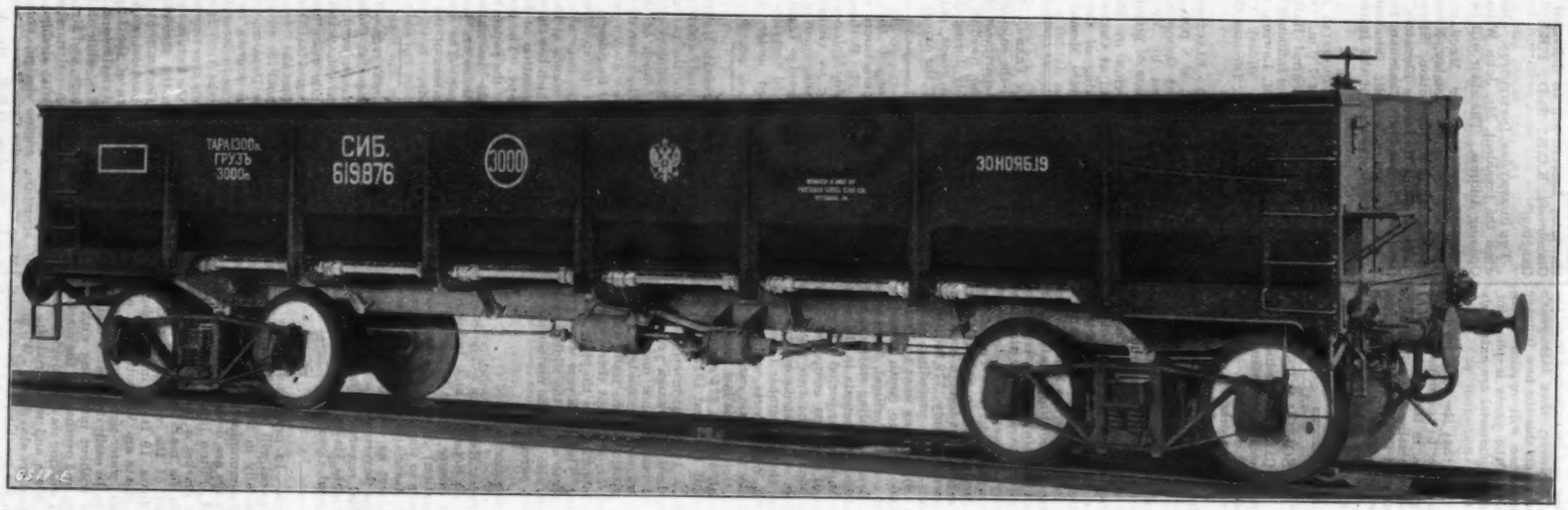
"THE MINING ELECTRICAL ENGINEER."—Electricity is ever playing an increasingly active part in mining work of all kinds, and in view of the varied nature and extent of the work involved, mining electrical engineering has become an important branch of the engineering and electrical professions. The interests of the branch have been represented for some eleven years by the Association of Mining Electrical Engineers. This association is a very active body and its latest important movement has taken the form of the issue of a monthly periodical bearing the title which stands at the head of this paragraph. The journal, which has the same size of page as the journal of the Institution of Electrical Engineers, is published at 1*s.* a copy. The contents are not confined to reproductions of the papers read and discussions held at meetings of the association, and descriptive matter and general articles are included on the lines of a technical newspaper. The journal should be of value both to the members of the association and to engineers who are outside.

EDUCATION IN AERONAUTICS.—The Department of Aeronautics at the Imperial College of Science and Technology, it will be remembered, was established early in the current year to give effect to the scheme proposed by the Committee on Education and Research in Aeronautics in their report issued last December, in which the opinion was expressed that the "Imperial College should become the central school for advanced study in aeronautical science." The Department is now in working order and two full-time courses, covering, respectively, design and engineering and meteorology and navigation, have been arranged for the 1920-21 session. The course of study normally extends over two years, the first of which will be spent mainly in the lecture rooms and laboratories of the college, while, in the second year, students will attend at one of the Government Research Establishments or at some aeronautical works. The full course leads up to the Diploma of the Imperial College. The Zaharoff Professor of Aviation and Director is Sir R. T. Glazebrook, K.C.B., F.R.S., while Sir Napier Shaw, F.R.S., is Professor of Meterology, and Mr. L. Bairstow, C.B.E., F.R.S., is Professor of Aerodynamics. The five lecturers who deal respectively, with airships, navigation, strength of structure, engine design, and general design are Wing Commander Cave Brown Cave, C.B.E., Squadron Leader Wimperis, O.B.E., Mr. A. J. Lutton Pippard, M.B.E., F.R.Ae.S., Mr. A. T. Evans, and Mr. F. T. Hill, A.F.R.Ae.S. The syllabus of both courses can be obtained from the college, the address of which is South Kensington, London, S.W.7.

50-TON STEEL GENERAL SERVICE CAR.

CONSTRUCTED BY THE PRESSED STEEL CAR COMPANY, PITTSBURG, PA., U.S.A.

(*For Description, see Page* 604.)



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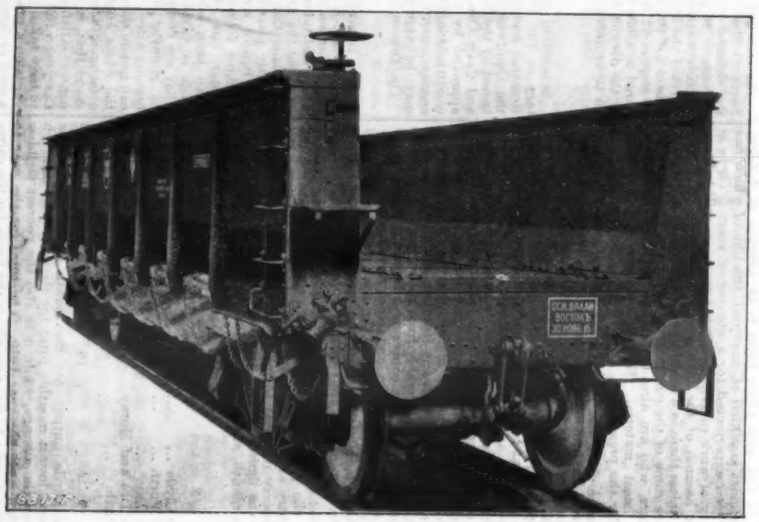

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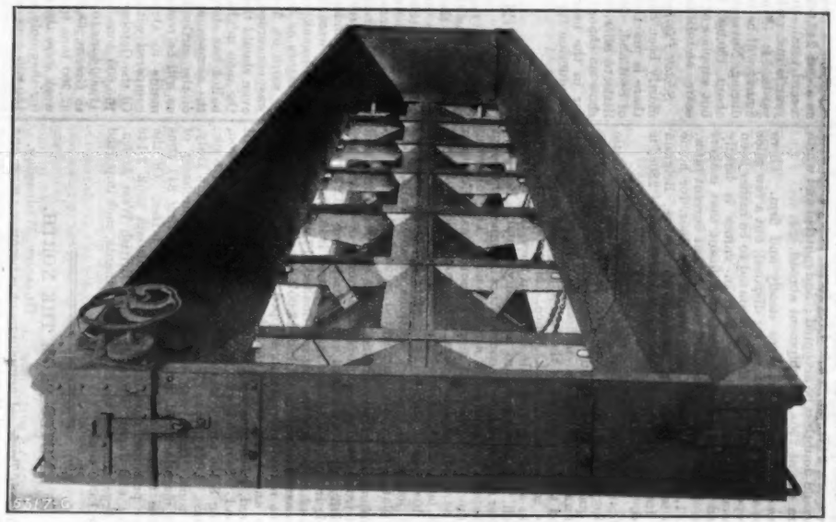

FIG. 16.

50-TON STEEL GEN RA

CONSTRUCTED BY THE PRESSED STEEL CAR

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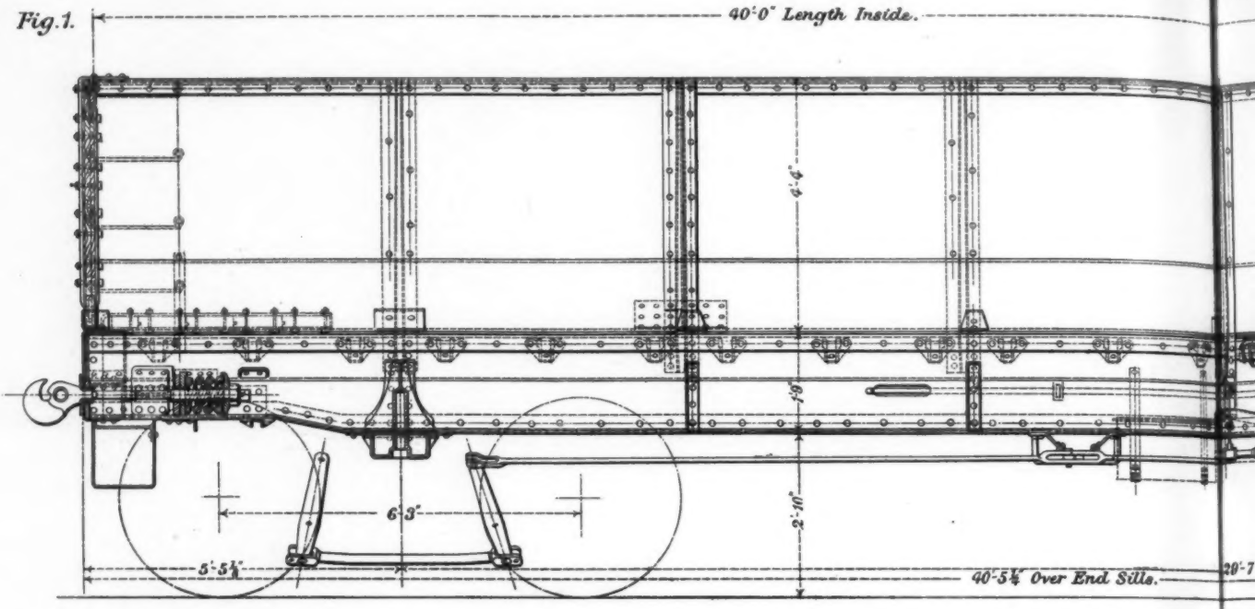

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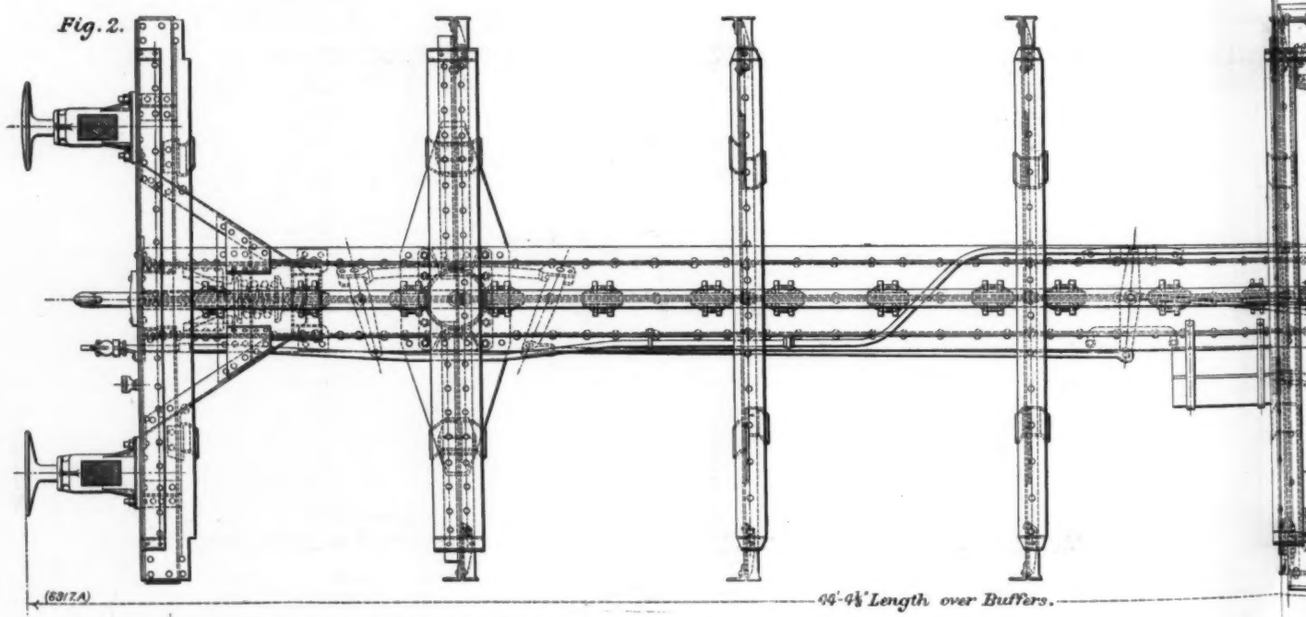

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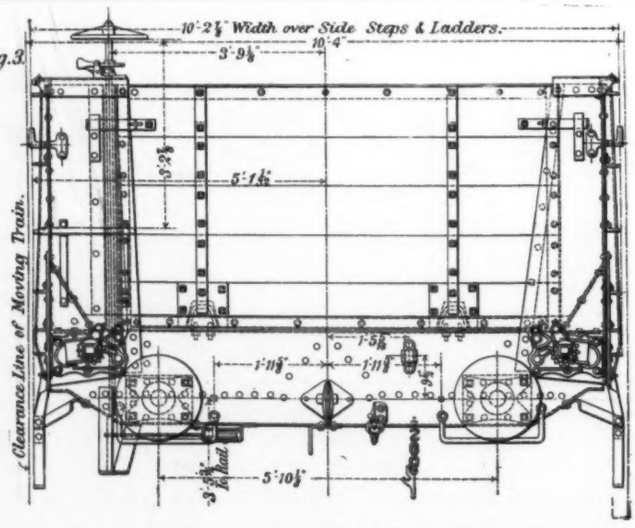
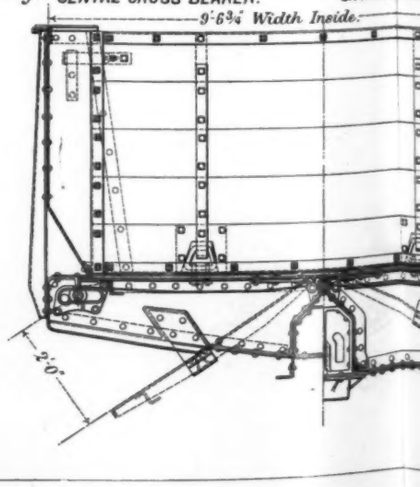


Fig. 4. SECTION A.A. SHOWING CENTRE CROSS BEARER.



GENERAL SERVICE CAR.

SED STEEL CAR COMPANY, PITTSBURG, PA., U.S.A.

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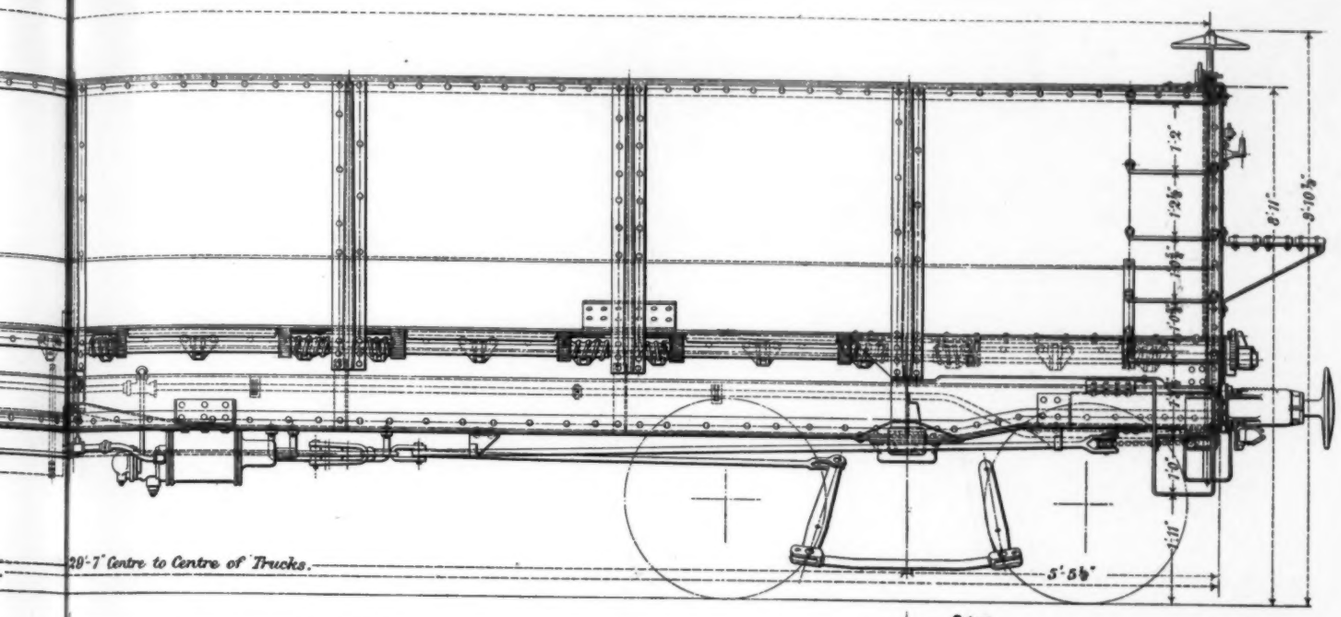
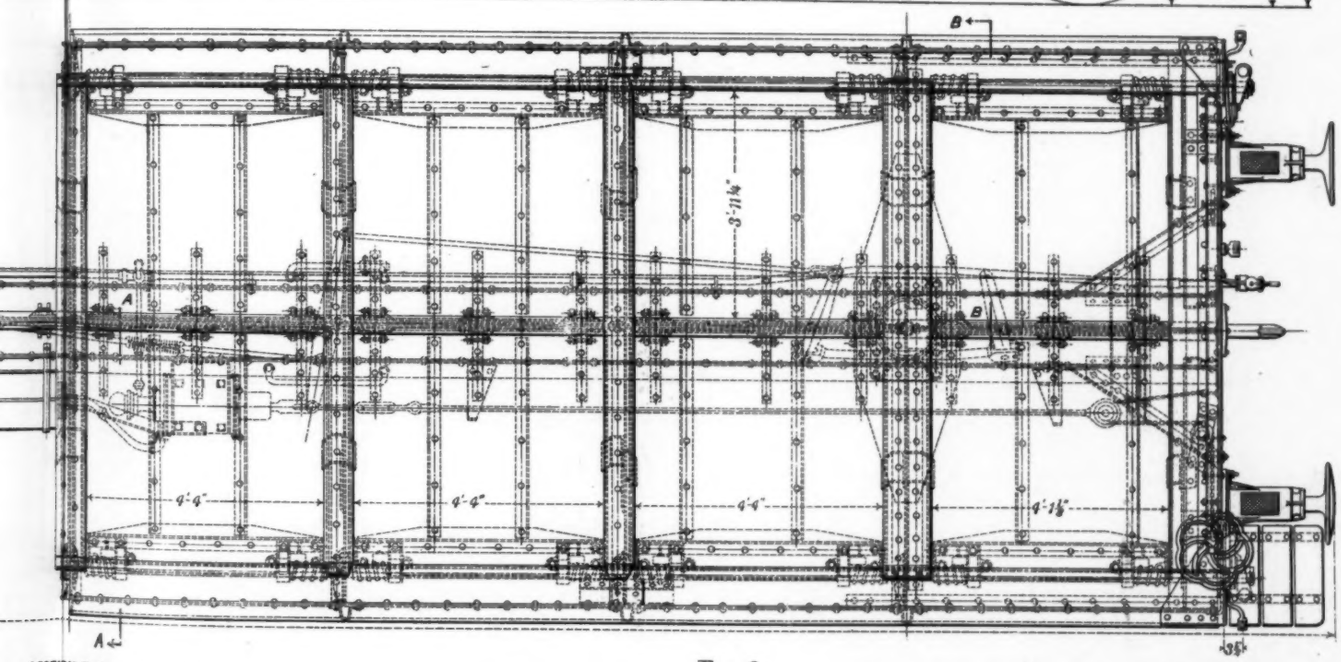




SECTION B.B. SHOWING BOLSTER. *Fig. 5.*

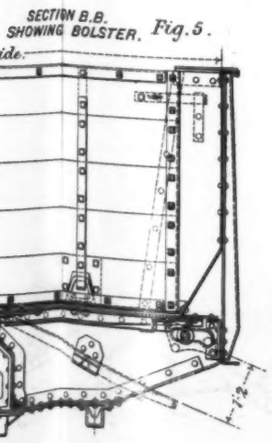
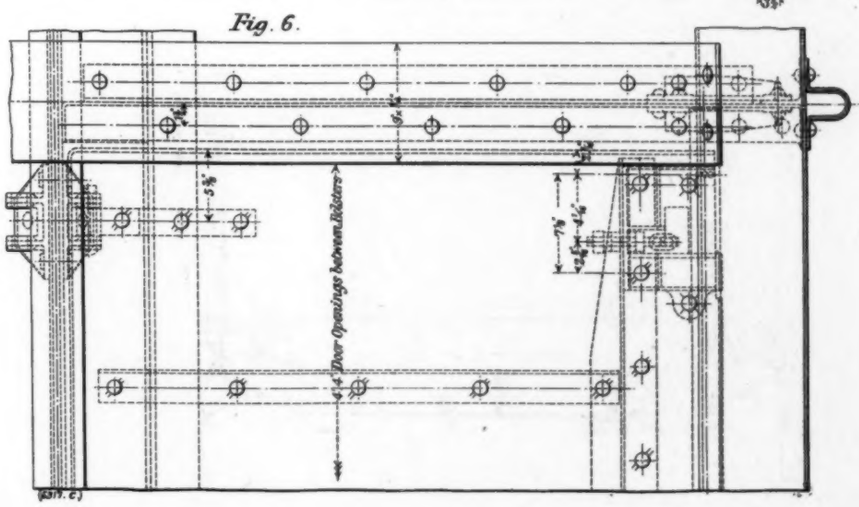


Fig. 6.



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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Thick ,, ,,	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
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TELEPHONE NUMBERS—3063 and 8598 GERRARD.

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With a Two-Page Plate of a 50-TON STEEL GENERAL SERVICE CAR.

NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 2½d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 607.

ENGINEERING.

FRIDAY, NOVEMBER 5, 1920.

URBAN ROADS.

THE effectual disposal of town traffic is a subject on which there is little hope of reaching a general solution. If we could decide, as used to be done in the Orient, to abandon existing towns and start again anew we might be able to tackle the problem properly. But when it comes to making the best of present circumstances, each case needs very special treatment. The proper planning of new areas adjacent to old, is nearly as difficult as the arrangement of the latter, for every district so developed commonly adds to the confusion and congestion of traffic in the older narrow streets, in the movements of the people to their work or homes, or of goods between factories, shops and warehouses.

As regards passenger transit in London we have had various suggestions, including new fast underground railways and high-speed underground motor ways. London, however, must always be a rather extreme case, and even here it may be doubted whether we shall see much new underground development for the relief of traffic. In few, if any, of the provincial cities and manufacturing towns could these methods be adopted, and such centres are almost compelled to look to road or ordinary railway transport for the future. The possibilities in the former direction constitute one of the topics discussed in the presidential address delivered on Tuesday last by Mr. J. A. Brodie, before the Institution of Civil Engineers, an address which we reprint in full elsewhere in our present issue.

In this valuable address, Mr. Brodie expressed the view that the time was ripe for radical improvements in connection with the longer-distance systems of tramway transport. Exactly what these radical improvements are to be cannot yet be definitely stated, but Mr. Brodie evidently looks for a greatly improved and accelerated tramway service with noiseless cars on resilient tyres, running on special fenced-in tracks in the centre of wide thoroughfares. He spoke of trams as quiet as the private motor car—an ideal which seems a little sanguine when it is considered that the contact bow or overhead trolley alone makes a very fair amount of noise which would not be reduced by modifications of tyres or track. The noiseless tyre would probably have to use rubber in some form, but then the flange becomes the difficulty, for in tramways we have to deal with the "guided type of vehicle." If a composite wheel were produced with a rubber tread and steel flange plate, the noise of the latter against the railhead might still be considerable.

If the high-speed tram car is to come into vogue in this country, some attempt must certainly be made to get away from the present heavy vehicle on a rigid track. In America the inter-urban systems afford convenient transit with a fair degree of comfort, for long distances, but the track for the most part is not of the rigid type developed to such a degree over here. It is more of the elastic character of our railways. Such track is already being attempted over here, but in towns and their suburbs is hardly ever possible save on the widest roads, where a special section can be devoted entirely to this service to the exclusion of all other. In outside areas, of course, the track can often be laid along the edge of fields, &c. The safety of other users of the road has to be considered, and it would probably be necessary to fence off the track for any system on which high sustained speeds are to be attempted. This again introduces questions regarding cross traffic in connection with which safety has to be thought of. In any case roads of sufficient width for such uses could hardly be provided on a large scale save in the yet undeveloped areas, where it may be comparatively easy to make such provision for the future. These help the congestion at the centre, however, only in a limited degree, and how to relieve this appears to be the crux of the problem. Had we ample width the system in vogue in some American cities would help. There there are sometimes four sets of street cars tracks, two for a stopping service, and the other two for a so-called express service, the latter being attained by merely cutting out the passenger stops, and not by any higher maximum speed. There are no towns here where improvements necessary for such a service can be carried into the heart of things at a reasonable cost.

The proposal is made in Mr. Brodie's address that the cost of widenings should be met partly out of the net profits on municipal tramway undertakings, partly out of the local rates, and in part by contributions from a central authority. At first sight the distinction between the two former may not appear very real, as if the tramways are municipal enterprises, it may be asked what is to be gained by charging high fares to make a profit for use in this way, in lieu of raising the same amount by rates? The money has to come out of the towns peoples pockets either way. There are, however, good reasons for charging a portion of the cost directly on those by whom the tramways are used. It is the fashion now-a-days to juggle with local finance, as in the housing schemes where the investor first lends his money, and then has to pay heavy rates to pay himself interest. Even a contribution from a Central Authority has first to be collected in taxes, but there is sometimes excuse for asking for these grants since an improvement is often required for the benefit of a neighbouring area, in which case the latter should certainly contribute directly or otherwise.

Although we would like to take the large view in these matters and plan for posterity we have to recognise that at present the country is already loaded with heavy financial shackles. With the reduced production per head, and prospects of a still greater decrease if one school of thought makes headway, it will not be at all surprising in the next decade or so to see a marked increase in emigration, with a decrease of population here. It is certain that we cannot continue indefinitely to import food and do less and less work to pay for it by exports. If a serious diminution of the population here occurs for these reasons where then will some big schemes be with their crushing costs?

It is, of course, natural that the municipal engineers and others concerned in the development of important cities should be anxious to carry out improvement schemes of a somewhat far-reaching character, but if their minds were turned to decentralisation some of the costly improvements might be saved. It has been proposed that in such schemes the smaller bodies should be continued under the expert guidance of a leading engineer so that the undoubted skill of our principal municipal engineers would still find ample employment, and if their energy were directed in this manner the greater good might result. We should still want arterial roads, but only to a reduced degree would it be necessary to provide for the concentration of traffic.

Mr. Brodie speaks without enthusiasm of the chess board plan of town streets. One often hears the merits of the rectangular system described by persons who have had some small experience of it across the Atlantic, but it is commonly overlooked that in many sites where rigidly carried out according to the plan the result has been almost ridiculous. If a town is built on hills (as many of ours happen

to be), the roads are carried in their straight lines over most unsuitable sections which could be much better laid out otherwise. In several cities this has led to many streets being on such gradients as to render them absolutely impossible for traffic so that though paved with sets they have become grass-grown and neglected. In one city a little while ago street after street, all parallel, could be seen in this condition.

There is a suggestion to make use of the unemployed ex-service men on road building and Mr. Brodie says he knows of no direction in which such unskilled labour can be so usefully employed. While agreeing that this course will serve temporarily to help both the ex-service men and the towns, we would strongly urge that those men who, to use Mr. Brodie's words, "owing to war conditions, have missed the opportunity of receiving a training" should now have the chance of acquiring the skill and knowledge of which the war has deprived them. If we do not do this and are content to employ them in great numbers on unskilled work we are lowering our abilities as a nation compared with our pre-war standards, and when the road schemes are finished as far as finances will permit, we shall again have a surplus of unskilled labour for which some fresh job must be found.

THE BREWERS' EXHIBITION.

In spite of the many restrictions still imposed upon the sale of the products of the brewer and distiller, the thirty-seventh exhibition and market of the brewers, distillers and allied traders seems to indicate that these industries have not suffered to any material extent. The exhibition, which opened on the 30th ultimo, at the Royal Agricultural Hall, and closes to-day, contains a very comprehensive display of machinery and labour-saving appliances, which compares quite favourably with previous exhibitions, and should prove of interest to engineers in general as well as to persons directly connected with the trade. The space at our disposal, however, does not permit us to give a detailed account of the whole of the technical exhibits, and we propose therefore only to refer briefly to such mechanical appliances as appear likely to be of direct interest to our readers.

The machinery most in evidence is that for washing and labelling bottles, about a dozen firms showing plant for this purpose. Many of the labelling machines are exceedingly ingenious appliances, but that which appeared to us to be the most interesting was the O. and J. automatic labeller shown at work on the stand of Messrs. R. W. Webster and Co., Limited, Dashwood House, New Broad-street, E.C. 2. This machine is capable of affixing both neck and body labels on pint bottles at the rate of 100 bottles per minute, but it can be arranged to apply any style of label, or combination of labels, to any round bottle, jar or tin. The bottles are fed into the machine in a vertical position by a band conveyor and passed on to a horizontal rotary table by means of an automatic feeder. They are clamped to the table and travel on it to mechanism which places a gummed label in position and then on to a wiper of thick soft rubber which presses the label into contact. The clamping device is released just before the bottle reaches a rotating turret provided with semi-circular arms which engage with the bottle and remove it from the table on to the band conveyor for delivery. Hand-fed labelling machines and label gummers are also shown at this stand.

The Purdy Patent Machinery Company, Limited, 10, Euston Buildings, George-street, N.W. 1, also show an automatic labelling machine with conveyor feed capable of working at two speeds, delivering 45 to 50, or 100 to 120 bottles per minute. The firm's well-known "World" labellers, which are hand-fed machines, are also shown, together with a small machine for applying labels over the screw stoppers, or corks, of bottles. Another interesting machine shown is used for pressing lead capsules over corked bottles, and its special feature is that only two uniform creases are formed, diametrically opposite each other, instead of the usual irregular crinkles. The pressing is effected by two cylindrical pads of soft rubber and the creases are formed by the joints between the two pads. The same firm show a syphon bottle-filling appliance, in which the liquid is supplied to a small rectangular tank through a float valve which keeps the level constant. It is drawn off by a number of U-shaped syphon tubes under which the bottles are placed, the act of placing the bottle in position opening a valve in the syphon and allowing the liquid to flow. The flow, of course, ceases as soon as the level of the liquid in the bottle is the same as that in the tank. Similar appliances were shown by several other firms, and in some cases the supply tank is circular and arranged to rotate so that the filled bottles can be supplied continuously to a corking machine.

Messrs. H. J. West and Co., Limited, 72 and 74, Gray's Inn-road, W.C. 1, show a complete bottle-washing and filling plant capable of dealing with 200 dozen bottles per hour. The plant comprises a soaking machine, brushing machine, rinser, draining table, drying machine and filling machine, and also includes a gravity roller conveyor for the crates, or cases, containing the bottles. Another interesting exhibit at Messrs. West's stand is a high-speed ammonia compressor, but as we hope to deal with this more fully in a subsequent issue we need not make further reference to it here. Complete bottle washing, filling and labelling plant is also shown by Messrs. G. Hopkins and Sons (Clerkenwell), Limited, 40 to 52, Holloway-road, N. 7; Messrs. R. Powley and Sons, Limited, Sunderland; the Brewers' Equipment Company, Birmingham; and Messrs. J. W. Flower and Co., Wimborne, Dorset; while Mr. D. G. Binnington, Hull, shows bottle-soaking, brushing, rinsing and filling machines, but not labellers. The last-named firm shows also bottle-corking machines for both cylindrical and "Crown" corks; a corking machine for cylindrical corks is also exhibited by Messrs. Flower. The Crown Cork Company, Limited, 71 to 89, Paul-street, Finsbury, E.C. 2, include among their exhibit of "Crown" corking machines a new model for bottling carbonated beverages. In this machine the bottles are first supplied with a measured quantity of flavouring syrup and afterwards filled and crowned under pressure. The machine will fill 500 dozen pint bottles a day.

Before leaving the subject of bottling plant mention should be made of the exhibit of Mr. Thomas Hill, of Hull, who specialises in bottle-cleaning machinery, and shows, amongst other appliances, a unit designed for cleaning small bottles and vials which cannot be brushed internally in the usual way. This unit comprises a three-compartment tank of galvanised steel, fitted with portable trays, in which the bottles are placed. The bottom of each tray is perforated and the top is also provided with a perforated cover. In working, one of the trays is filled with bottles placed with the mouths uppermost, and with the cover in position, the tray is placed in the tank, which is partially filled with water. The bottles, of course, fill with water so that floating particles escape, and after soaking thus for 10 minutes, the tray is raised and turned over to allow the water to run out and carry with it any foreign matter which may have deposited. The tray is treated similarly in the two other compartments of the tank, so that each bottle is filled and emptied three times with separate liquids, which may be either hot or cold water, or soda solution. Bottle-cleaning plant is also shown by Messrs. Farrow and Jackson, Limited, 16, Great Tower-street, E.C. 3.

For many reasons a supply of pure air is of great importance in brewing operations, and, to secure this, Messrs. G. J. Worssam and Son, Limited, Wenlock-road, City-road, N. 1, make the Fox-Cole air-purifying machine, in which air may be freed from micro-organisms and other impurities, while, at the same time, it may be warmed or cooled according to requirements. The air is first drawn by a fan through a washer, and afterwards passed through the purifier which consists of a horizontal cylindrical casing enclosing a rotating drum and a series of corrugated cylinders arranged concentrically around the drum; the corrugations, it should be mentioned, are circumferential and not longitudinal. The cylinders dip into a solution of dilute glycerine and boric acid, and the air passing between the cylinders comes into contact with the wet surfaces of the latter, on which the impurities are caught; the solution adhering to the cylinders is, of course, renewed at each revolution. The purifier is designed so that it can easily be rendered completely sterile by boiling water, the water being heated by steam within the purifier itself. If the purified air is required to be heated, it is passed through a steam heater after leaving the purifier. Messrs. Worssam also show plant for collecting the carbon dioxide produced in fermentation, and compressing it for use in bottling beer. The design of the compressor used, which is of the two-stage type, is interesting in that special precautions have to be taken to prevent the temperature of the gas from rising above 100 deg. Fahr. in order to avoid the decomposition of the esters present in the gas, as these have an important effect upon the flavour of the beer. Another exhibit at Messrs. Worssam's stand is a small portable, electrically-driven rotary pump, called a "rousing pump," which is used for drawing off worts from a vat during the process of fermentation and returning it through a spraying nozzle. The object of this device is to effect the aeration, and consequent oxygenation, of the worts, and, at the same time, to mix the different constituents thoroughly.

Of Messrs. Worssam's other exhibits we need only refer to a four-roller mill for grinding malt, of the type formerly made in Germany by Messrs. Seck. Malt grinding mills of English design throughout are shown by Messrs. George Porteus and Sons (Leeds), Limited, of Leeds, examples of eight-roller mills and four-roller mills being included in the exhibit of this firm, as well as rotary cylindrical malt screens, a rotary dresser for cleaning barley preparatory to malting, a blender for mixing English and foreign corn in the desired proportions, and a combined screen and grader for separating the large grains of malt from the small. The last-mentioned machine is placed over the malt-grinding mill, so that the smaller grains are ground on one side and the larger grains on the other. The malt mills of this firm, it should be mentioned, are provided with cylindrical self-cleaning screens, the cleaning being effected by means of internal rotating brushes and finger beaters.

Maltster's plant also forms the major portion of the exhibit of Messrs. Robert Boby, Limited, of Bury St. Edmunds, the most noticeable item on their stand being a barley-sweating drum capable of treating 50 quarters at a time. The sweating drum consists of a cylindrical vessel, 15 ft. in length and 8 ft. 6 in. in diameter, constructed of steel boiler plates and mounted on rollers so that it can be slowly rotated by gearing. Its purpose is to reduce the moisture in the barley from, say, 20 per cent. to about 11 per cent., and to ensure that this percentage of moisture shall be uniform throughout the whole of the grain. Six semi-circular perforated tubes are attached to the shell plating inside the drum, the tubes being placed at equal distances apart parallel with the axis. Another large cylindrical perforated tube is fixed in the centre of the drum concentrically with the shell plating, and, at one end, this tube is connected to an exhaust fan. The six other tubes open into a space formed by a false end to the drum, and this space is in connection with a brick furnace in which gas coke or anthracite is burned. The effect of the fan is thus to draw the hot products of combustion from the furnace through the outer perforated tubes, and through the grain in the drum into the central tube, whence they are discharged together with the moisture extracted from the grain. The same appliance is also used for drying, or "re-torrifying," the malt before it is used for brewing.

Messrs. G. Hopkins and Sons (Clerkenwell), Limited, whose address will be found above, have a very striking exhibit of cask-washing machines, including one known as the "Super Goliath." This machine can cleanse, internally and externally, about 240 barrels per hour, ranging in size from firkins to hogsheads. Three washing, or steaming, nozzles are placed in a line at one end of the machine, and the barrel is transferred from one to the other by means of a rotating frame operated by overhead

gearing. As each barrel is deposited on to the nozzle its weight, opens the valve supplying steam, or hot water, to the interior, so that the action is entirely automatic. After passing over the three nozzles, the barrel is passed on to rollers which cause it to rotate rapidly against stationary brushes supplied with water for cleaning the external surfaces, and, after this operation is completed, the barrel passes over three additional steam and hot-water nozzles at the other end of the machine for further interior treatment. Ingenious mechanism, which owing to lack of space cannot be described in detail, is provided to rotate the barrel into such a position after it has been brushed externally, that the last three washing and steaming nozzles will enter through the bung hole. A special turntable is provided at the extreme end of the machine to turn the barrel into the required direction for removal.

Several firms, including Messrs. Hopkins, Messrs. G. Adlam and Sons, Limited, Bristol, and Messrs. H. Pontifex and Sons and Farringdon Works, Limited, Shoe-lane, E.C. 4, show beer-chilling plant. That of the first-mentioned firm is of the counter-current type, in which a coil composed of two tubes, one arranged concentrically inside the other, is employed. The beer is passed through the central tube, and brine, or other cooling fluid, is circulated in the opposite direction through the annular space between the inner and outer tubes. In Messrs. Adlam's chiller the beer is allowed to trickle over the surface of a vertical stack of tubes of sugar-loaf section, through which cold water is circulated. Messrs. Pontifex, on the other hand, employ three different systems of chilling, examples of which are shown on their stand. These include the firm's combined chiller and carbonator, apparatus in which the beer is chilled in a copper tank containing a brine cooling coil, and a third arrangement designed on the counter-current system. In the latter, the beer is drawn by a centrifugal pump from the Pfaudler tank, passed through the counter-current cooling coil and returned to the top of the tank through a diverging nozzle. A connection is made on the return pipe near the tank to a CO_2 bottle, the gas from which passes into the tank with the beer and carbonates it. The tank itself is either carefully lagged, or kept in a cold room. Messrs. Adlam also show a filter press in which the filtering medium is wood pulp. The filter units are composed of gun-metal discs formed with annular ridges which hold the pulp in position, and inside the mass of pulp is a disc of wire gauze which provides a passage for the filtered liquid.

Although the exhibition includes many fine examples of the cooper's craft, machinery for this class of work was shown by one firm only, viz., Messrs. James Stewart and Co., West Dunedin-street, Edinburgh, and their exhibit, although interesting, was by no means extensive. This firm showed a gas-heated branding machine for cask ends, and small portable, hand-operated brands, also heated by gas. Their most interesting exhibit, however, was a shive-turning machine for making the wooden bungs for barrels. Shives are usually made by sawing discs from a board by means of a tubular saw, the discs being afterwards tapered and finished in a lathe. In Messrs. Stewart's machine, which is similar in principle to a sensitive drill, the shives are finished in one operation. This machine is provided with a cutter head running at 3,500 r.p.m., and fitted with four vertical knives for cutting out the disc, and two additional knives set at an angle to impart the necessary taper. Another knife is provided to clean up the large diameter edge of the shive and to give it a slight chamfer. The work is held stationary by a prong chuck on the bottom plate of the machine, and is pushed up through the knives by means of a foot pedal. The output of the machine, we understand, is 10 gross per hour, and it is driven by an 8-h.p. motor.

Among the many appliances shown for handling goods in breweries and bottling stores, we should mention a portable crate elevator used in conjunction with a gravity conveyor and exhibited by Messrs. Rownson, Drew and Clydesdale, Limited, 225, Upper Thames-street, E.C. 4, and also a portable crane of the electro-hydraulic type shown by Messrs. J. W. Flower and Co., of Wimborne, Dorset. In this crane, which is largely used for stacking casks in wine vaults, and other work of a similar nature, an electric motor drives a three-throw pump which forces oil into a hydraulic cylinder. The cylinder is mounted vertically on a three-wheeled base plate, and the jib is fixed horizontally to the upper end of a ram working in this cylinder. The lifting chain passes round two pulleys, one fixed to the cylinder casting and the other mounted on the rear end of the jib, before running over a third pulley at the lifting end of the jib down to the hook, so that the movement of the latter is twice that of the ram. Hand-slewing gear is provided, and the crane is hauled about as required, also by hand, power being supplied to the electric motor through flexible cables connected to wall plugs situated at convenient intervals. The crane exhibited was suitable for working loads up to 6 cwt., but we understand that other sizes are made for loads up to 1 ton, and that self-propelling cranes, of similar design, can also be supplied.

Some excellent examples of welded aluminium tanks and other vessels for breweries are shown by the Aluminium Plant and Vessel Company, Limited, Wandsworth, S.W. 18, their most notable exhibit being a 30-barrel tank for conditioning beer under pressure. The tank is 9 ft. long by 5 ft. 3 in. in diameter with rounded ends, the body being formed from a single sheet about $\frac{1}{4}$ in. thick, with one longitudinal weld. An aluminium cylindrical tank for transporting beer in bulk on a motor lorry, is also shown, and another item of interest is a large, rectangular wagon for conveying yeast. Yeast wagons, it may be mentioned, are usually made of wood or slate, and aluminium has several advantages over either of these materials. The most obvious advantages are that it is lighter and easier to clean. Mention should also be made of a large open fermenting vessel shown by the Enamelled Metal Products Corporation, Limited, Imperial Buildings, Kingsway, W.C. 2. This vessel is constructed of steel in three rings, 10 ft. in diameter internally, and has a total depth of 9 ft., its capacity being 125 barrels. The steel is coated internally with glass enamel, which extends over the flanges of the rings so that the contents of the vessel cannot come into contact with the steel. The rings are bolted together, the joints being made with a special non-absorbent and tasteless material. Small enamelled steel pans for containing corrosive liquids and chemicals are also shown by the same firm.

Of the remaining engineering exhibits we should mention the "Turbine" patent boiler furnace, but as this will be illustrated and described in a subsequent issue it need not be dealt with here. A number of well-known makers exhibit steam wagons specially arranged for brewers' transport work, and of these we may mention Messrs. Fodens, Limited, Sandbach, The Sentinel Wagon Works, Limited, Shrewsbury, Messrs. W. Tasker and Sons, Limited, Andover, Messrs. W. Allchin, Limited, Northampton, and Messrs. R. Garrett and Sons, Limited, Leiston. The latter firm show a 3½-ton electric vehicle, as well as their well-known steam wagon.

CAPTURED ENEMY MECHANICAL TRANSPORT VEHICLES.

One of the greatest developments of the late war was the extensive use of mechanical transport vehicles. A great deal has been published about the use of these in our own Army, and the types of vehicles, &c., are very well known, but there has so far been very little available information as to the appliances in use by the enemy. A great deal of interest attaches, therefore, to the collection of captured enemy vehicles now at Aldershot, a collection which our representative was allowed to examine last week by the courtesy of the Military Authorities.

These examples number about 50, and were carefully selected out of the thousands of abandoned and captured transport vehicles as representing the most interesting representatives of enemy practice. They were selected by Lieut.-Colonel Hutchinson, Chief Inspector of Mechanical Transport, after a personal examination of some hundreds of different vehicles of all sorts, and it is mainly due to his efforts that they have been got over to England. Many difficulties were encountered, as after the Armistice there was a very general feeling that the "war was over" and things did not matter, added to which the demobilisation of the Army was the only thing which occupied most people's minds, and transport was most difficult to obtain. The only labour available was incompetent or worse. These difficulties were, however, surmounted through the efforts of Colonel Hutchinson and his assistants, especially Captain M. Payne and Captain A. R. Hope, both R.A.S.C., and the vehicles are now at Aldershot. The difficulties will be realised when it is stated that in some cases the only way of moving the vehicles was for one of the above officers to drive a borrowed traction engine with his own hands. The vehicles are mainly of two classes, firstly tractors for drawing artillery, secondly lorries. There are also three or four ordinary cars. The dimensions and particulars of the tractors and lorries are given in the Tables I and II, which we give on pages 613 and 614. Of the 50 vehicles several are duplicates, so that the number of different examples in these two classes is 32, *i.e.*, 15 tractors and 17 lorries and cars.

Broadly speaking, the problem before the enemy with regard to transport was the same as ours, but there were several differences. One was the fact that supplies could not be obtained from America, and another was that there was a great shortage of rubber. Whether these altogether account for the different way in which the problem was attacked, it is impossible to say.

There were two main classes of work to be done: the haulage of heavy artillery and the carriage of supplies and ammunition. For the latter, lorries were employed of generally similar design to ours, but differing in some important points. For the haulage of the guns, however, the type of machine used was very different from ours. In the English Army the heavier guns were almost entirely moved by the Holt caterpillar, while the lighter howitzers were moved by four-wheel-drive lorries, both these being American machines intended for commercial work. A few large petrol tractors of the wheeled type, of English make, were used for the 15-in. howitzers, but these were very few in number. The Germans, on the other hand, used almost exclusively wheeled tractors of considerable size for haulage, and these were in all cases specially built for military purposes. They were fitted with really powerful winding drums and ropes, generally with very efficient fairleads, so arranged that the lead could be taken in any direction. Undoubtedly, there are very great advantages in such machines over any which are manufactured for purely commercial work. Our caterpillars were very slow, most of them having only one speed, and it was found that they were not well suited for travelling long distances on the roads, especially when these were pavé. Under such circumstances the wear and tear were excessive, while the slow speed (about 2½ miles an hour) was a great hindrance. The absence of a winding drum was also a great disadvantage, for in difficult ground far the best way of moving such an object as a gun is usually for the tractor to stay still and haul the load with a rope, which can be taken round a snatch-block if necessary. The petrol consumption of a track-type machine with one speed is also very high compared with that of a wheeled vehicle with several speeds.

For all these reasons there appear to be considerable advantages in the tractor of the type used by the enemy. It is very interesting to note that in 1909 trials of such machines were made by the British military authorities, and a very useful type of machine evolved. Had this type been developed between then and 1914, we might have had a nucleus of tractors of very efficient type which we could at once have started manufacturing here in quantities, and we should then not have been dependent on foreign commercial vehicles which were never designed for military purposes.

In main outline, the German tractors follow lorry practice, that is to say, they all have vertical engines placed longitudinally in the front of the

machine, driving the back wheels by chains or gears. The back wheels are generally of large size, the proportions of back and front wheels following traction-engine practice. Steel tyres are invariable, and four-cylinder engines almost universal. Steering is invariably by Ackerman axle. In most cases both axles are carried on springs, allowing of a considerable amount of motion, and the tractors are capable of considerable speed, in some cases up to nearly 20 m.p.h.

The weights of the machines are of great interest. It will be seen that the engines are in all cases of considerable size. The actual horse-powers are not available, but a well-designed petrol engine of this type should be able to develop a horse-power for each 8 cub. in. of cylinder capacity, and on this assumption the brake horse-power would vary from about 75 to 135.

In this connection, the Mercedes tractor is undoubtedly very interesting. The engine has cylinders 5·9 in. diameter by 6·7 in. stroke and should, therefore, develop about 90 brake horse-power. Yet the actual weight of the tractor is under 5 tons. On this account alone, therefore, the machine is well worthy of study, and it is further very interesting to note that it was a pre-war design especially made for military purposes. All four wheels are driven but, contrary to usual practice, they are not of the same size, the back wheels being a good deal the larger. Further, the drive for the front wheels is not through the usual universal joints, but through a vertical shaft on the line of the swivel pin which carries two bevel pinions one meshing with a bevel on the axle shaft, and the other with a bevel on the road wheel. Internal gear is used for the final drive of the back wheels. There is thus no attempt at making the various parts of the driving gear of the front and back wheels interchangeable, as is usual. Both front and back axles are attached to the frame by elaborate pressed steel radius rods, which also act as torque rods. Both axles have long leaf springs. A very substantial winding drum on a horizontal spindle is placed near the centre of the vehicle driven from the gear-box shaft by two pairs of bevel gears and a worm. This carries a long length of good-sized rope. A body to carry a certain amount of ammunition is provided, and this has numerous cupboards for carrying spares. This body, with the cupboard doors, &c., is almost entirely made of steel pressings, and is extraordinarily light. All parts of the vehicle are lubricated by a pump on the gear-box, which forces oil through pipes to the various parts requiring it. Electric light and self-starter were provided, but these have been removed. The road wheels are of wood with pressed steel rims. The whole is a most wonderful instance of how weight can be kept down by careful study of the various parts. To get a vehicle of this size with all four wheels driven and a large winding drum, fairleads, body, &c., down to a weight of 4·82 tons is a very great feat.

Generally speaking, the tractors do not have all the four wheels driven, but only the back. These are then of large size, ranging up to about 8 ft. diameter. They are built of steel, and some follow almost exactly the lines of general traction-engine practice, and in this case they appear to have been quite satisfactory. In other cases, however, the spokes are of channel section often badly riveted to the rim and hub, and in many cases these seem to have given a good deal of trouble from loose rivets. Great attention was paid to the matter of spuds, which are usually arranged so that they can either be withdrawn quickly inside the rim or alternatively are arranged so as to be very easily removable.

The most usual arrangement is shown diagramatically in Fig. 1. The spuds, AA, are steel pressings, and move through slots in the rim, being guided by rollers. BB, which have flats on them where the spuds touch. The spuds are nearly the full width of the rim where they go through it, but are pressed into a U-shaped continuation, which is attached to the ring, C, by the pins, DD. This ring can be rotated round the hub, which causes the spuds to be pushed out or withdrawn at will. Necessarily considerable power is required to turn the ring, and in some cases a handle with powerful reduction gear is provided. In other cases the driving chain of the back wheels is attached to the ring, which can be fixed to the hub by pins in different positions. In this case, when the pins are withdrawn the power of the engine can be used to rotate the ring and push out the spuds. There are several variations of this arrangement, most of which are very well worked out, and appear to be thoroughly practical.

In the Mercedes tractor, detachable spuds are used of the pattern shown in Fig. 2. Here the spuds are very light steel pressings with a hollow rib right across the wheel and a rib down the centre. Each has a hook, E, at the front, and a tongue piece, F, at the end, which fits into a recess on the next spud. The hooks, E, go through holes in the rim, and each spud is locked in place by the tongue, F, being held down by the next spud. The last spud must, of course, be bolted.

The saving of time by using either of these arrangements over the usual one of having all the spuds bolted on, is very great, and it might very

Fig. 1.

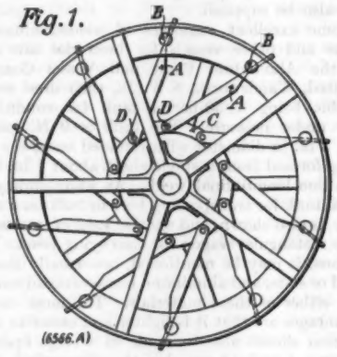


Fig. 2.

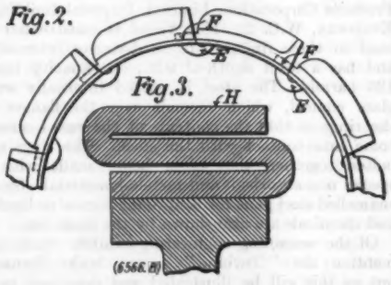


Fig. 3.

well repay our tractor makers to study them. Ordinary spuds take a great deal of time to attach and detach, and not only is this time wasted, but often the spuds are not removed when they should be and damage to machine and road results.

A curious feature of the transmission is that two sets of constant mesh gears are frequently provided to the layshaft of the gear-box. The gear-boxes are of the ordinary type, usually with four speeds, a pair of constant mesh wheels driving a layshaft through which the lower gears are driven. In several of the tractors there are two sets of constant mesh wheels which theoretically gives eight speeds. If Table I be examined, however, it will be seen that in practice the ratios, in many cases, are not so chosen as really to get this advantage. Thus in the Bussing the first speed with high constant mesh is the same as the second speed with low constant mesh. Again, the second with high constant mesh and third with low constant mesh are so nearly the same that the extra speed is no advantage. It would appear that the correct way of proportioning the gears in such a box would be to make the ratio between the two sets of permanent mesh wheels greater than that between the top and bottom of the ordinary change wheels and this is done in the Pohl tractor which, therefore, gets six progressive speeds. Two reverse speeds are, of course, one result of this arrangement.

The extensive use of steel pressings for various parts of the vehicles is very noticeable. Frames are usually of pressed steel, and are often of very complicated design, the side members having bends in every direction. This can hardly be called good design, but the manufacturers appear to have made a wonderful job of carrying out very difficult work. Radius rods spuds, spokes, spring brackets, and many details, are often made of these steel pressings. Front axles are of various kinds, in some cases being built up of plates. They are generally well sprung, in some cases having the usual semi-elliptic springs of a lorry, in others having a central pivot, and one spring to avoid twisting the frame of the vehicle.

Winding drums are generally of substantial construction, and are either set on a horizontal spindle across the vehicle, or are set on a vertical spindle and arranged much like an ordinary steam plough engine. They generally carry a good length of rope, about 1 in. diameter. In some cases they have a well worked out automatic coiling gear, as is usual in English steam plough practice, but in many cases they simply have a hand gear traversing the fairlead across the drum to control the coiling. An interesting point is that many of the machines have road wheels so arranged that there is a very broad tread for going over rough ground and a narrow tread raised some 2 in. from it, for going on a hard road. This appears to have some distinct advantages, for the necessity for broad wheels on soft ground is obvious, but there are some distinct disadvantages in very broad wheels on a hard road.

One make of tractor had a rim of the peculiar section shown in Fig. 3, when H is the surface next the road. This design is presumably intended to give a certain amount of spring, and possibly also to enable the tread to set itself to the curve of a rounded road. It seems, however, doubtful to what extent the curve of the wheel would allow it actually to spring.

As these tractors evidently relied a great deal on their winding drums for getting the guns into position very substantial sprags, often of pressed steel, are provided. An interesting point is the use of automatic couplings for the guns. In several cases the rope passes through a fairlead so arranged that the trail of the gun can be hauled right into it and coupled there automatically. This may save a considerable amount of time in cases where roping has to be resorted to for short distances. In the tractor trials of 1909 it was shown that on anything like difficult ground it was quite a mistake to try and haul the load if the arrangements of the winding drum were satisfactory. The proper thing to do is to run on a short distance leaving the load and haul it afterwards with the rope. If the coupling arrangements and winding drum are really convenient, much less time is lost by doing this than by making serious efforts to haul the load directly over bad ground.

It is, of course, impossible, in the present article, to go into details of the construction of the various machines on view, but there is no doubt that there is a great deal to be seen which is of interest to those who are constructing or using tractors of any kind. The vehicles are the result, in many cases, of large experience in the use of tractors for the haulage of guns both on the road in soft ground, and although there are undoubtedly in some instances many faults in design, there is much to be learnt.

Although the Germans appear to have relied practically entirely on the wheeled tractor for haulage, the collection includes two examples of machines of the caterpillar type. Both were made quite at the end of the war. The first of these has a chassis of the same construction as one of the tractors, namely the Lanz. The tracks and track plates appear very similar indeed to those of the Holt, but the springing of the track rollers is different, and the track is much longer. Each pair of rollers is carried on one short leaf spring pivoted in the centre. The engine is in front, and gear-box at the back, as usual, and the sprockets of the track are driven through friction clutches. A steering-wheel is provided and by turning this either of the clutches can be freed for steering purposes. The other machine is very much more interesting, more especially as it formed the basis of the German tank which appeared towards the end of the war. In this machine each track is driven by a separate engine, the two engines being placed alongside

TABLE I.—TECHNICAL PARTICULARS OF CAPTURED SPECIMENS OF MECHANICAL TRANSPORT VEHICLES: TRACTORS AND GUN CARRIERS.

Make.	Type.	Engine.						Clutch.	Gear Ratios.					Frame Sections.	Road Wheels.				Wheel Base.	If Fitted with Winding Drum.	Overall Dimensions.			Total Weight.
		No. of Cyls.	Bore and Stroke.	Fitted Governor.	Lubrication.	Cubic Capacity.	Carburettor.		1st	2nd	3rd	Top	Reverse		Front. Diameter by Width.	Rear. Diameter by Width.	Overall Track. Front.	Overall Track. Rear.			Extreme Lgth.	Width	Hgth	
			In. In.			Cub. In.									ft. in. in.	ft. in. ft. in.	ft. in	ft. in.	ft. in.		ft. in.	ft. in.	ft. in.	Tons.
Ehrhardt (Tractor)	45-h.p. ..	4	5·35×6·3	Yes	Splash to big end. Forced to mains	567·6	Zenith pressure feed. Heated from manifold on exhaust pipe	Cone type. 16 in. diam. 3½ in. face ..	95–1 236–1	65–1 147–1	40–1 80–1	24–1 54–1	—	6 in. × 2½ in. × ½ in.	4 0×5½	4 0×0 5½	5 3½	5 4	14 3	Yes	24 0	7 4	9 10	—
Bussing (Tractor)	80-h.p. ..	6	5·31×5·9	Yes.	Splash from trough	786	Bussing. Gravity feed	Inverted cone type	100–1 200–1	50–1 100–1	High. 28–1 Low 56–1	19–1 38–1	100–1 200–1	6⅝ in. × 2½ in.	4 3×10	6 0×1 6	8 3½	7 0	12 0	Yes	20 10	7 0	—	8·2
Ehrhardt (Lorry)	4 wheel drive. A.A. gun mounting	4	5·35×6·3	Yes.	Splash to big end. Forced to mains	567·6	Zenith pressure feed. Heated from manifold on exhaust pipe	Cone type. 16 in. diam. 3½ in. face	64–1	38–1	23–1	14½–1	64–1	—	2 10×6	3 0½×0 4	6 1	6 6	13 1	Yes	23 4	6 8	7 8	5·35
Heinrich (Caterpillar)	2 engines	4 each engine	—	Yes.	Forced	—	Pressure feed. Heated from exhaust manifold	Double cone. Mercedes type	—	—	—	—	—	Built up type	3 2 diam. at turn	—	—	—	19 6 over-all	No.	24 6	9 3	—	—
Benz (Tractor)	4-wheel type	4	6·5 ×8·5	Yes.	Forced	1,128	Zenith pressure feed. Heated from exhaust	Multi-disc. Discs. 9½ in. × 1/17 in.	4 forward, 1 reverse				—	10 in. × 3½ in. × 1/16 in. front)	3 11½×10	6 1×1 6½	7 0	7 6	13 1	Yes	21 0	7 6	—	9·7
Horch (Tractor)	4-wheel type	4	5·5 ×6·5	Yes	Splash to big end. Forced to mains	618	Gravity feed. Heated from exhaust manifold	Cone type. 18 in. × 3 in. race	4 forward, 1 reverse				—	8 ft. × 2½ in. (rear)	4 1×10	5 11×1 5½	6 10	7 2	11 10	Yes	20 0	7 2	9 0	7·31
Durkopp (Tractor)	4-wheel type	4	6·25×7·0	Yes	Splash to big ends and cylinder walls	859·2	Gravity feed. Hot air intake	Internal cone	130–1 250–1	72½–1 132½–1	High 45–1 Low 82½–1	29–1 52½–1	130–1 250–1	—	3 11×9½	7 4×1 5½	7 6	7 6	13 6	Yes.	21 0	7 6	8 10	7·45
Podeus (Tractor)	4-wheel type	4	6·3 ×7·87	No	Rings. Big ends. Cam feed Cylinders and all bearings	981·6	Solex Gravity feed. Heated from exhaust manifold	Plate type. 18 in. outside casing	4½–1	6½–1	9½–1	13–1	—	8½ in. × 3 in.	4 8× 9½	8 2×1 7	6 8	7 10	13 0	Yes	22 4	7 10	10 0	9·11
Mercedes (Tractor)	4-wheel drive	4	5·91×6·69	No	Forced	733·2	—	Mercedes type. Double cone	140–1 47–1	96–1 32–1	Low 52–1 High 17½–1	32–1 11–1	140–1 47–1	—	3 11½×7½	4 5½×1 2½	6 9	7 0	11 2	Yes	20 4	6 7	10 6	4·82
Diotz (Tractor)	100-h.p.	4	6·3 ×7·87	Yes	Pump independent feed to mains and by centrifugal to big ends (web rings)	981·6	Pressure feed. Heated from exhaust	Cone type. 24 in. diam. 4½ in. face	1st Train. 30–1 2nd Train. 98–1	82–1 174–1	62–1 208–1	— —	82–1 194–1	3 in. × 8 in.	4 1× 9½	7 4×1 6	7 3	7 0	11 8½	Yes	21 0	7 3	9 5	9·66
Mercedes (A.A. lorry)	4-wheel drive	4	5·51×6·3	—	Forced	601·6	—	Mercedes type. Double cone	8 forward, 2 reverse			—	—	6½ in. × 3½ in. (at centre)	2 8×5½	2 6×1 0	5 7	5 7	12 7	—	20 0	6 10	5 6	4·5
Pohl (Tractor)	4-wheel ..	4	6·3 ×7·87	Yes	Cam independent feed-main for bearings, timing gears and cylinders. Centrifugal web rings for big ends	981·6	Solex. Gravity feed	Cone feed. 24½ in. 4½ in. face	140–1 40–1	90–1 24–1	58–1 15–1	— —	80–1 24–1	—	4 2× 9½	5 9½×1 5½	7 5	7 2½	12 8	Yes	20 3	7 3	10 0	6·98
Lanz (Tractor)	4-wheel ..	6	5·91×6·3	Yes	Forced mains. Centrifugal web rings for big ends	1,035·6	2 pallas. Gravity feed. Heated through main bearing webs	Multi-plate plates, 19·685 in. diam.	192–1 84–1	Bottom 114–1 Top 49–1	38–1 29–1	— —	140–1 105–1	10 in. × 3½ in. × 25–64 in.	3 7× 9½	7 3×1 6	6 10½	7 3½	13 0	Yes	20 8	7 0	9 5	8·44
Pavesi ..	Tractor ..	4	—	Yes	Pump, Albany type	—	Zenith	Leather covered cone	101–0	37–0	25–0	16–5	80–0	½ in. × 3½ in. × 8 in.	2 11½×9	4 0×0 14 Caterpillar type wheel	6 8	6 10½	10 10	Yes	16 0	7 7	6 9	—
F.I.A.T. ..	Tractor ..	4	5·11×7·87	Yes	Forced feed ..	650	F.I.A.T. ..	Plate ..	150–0	57–0	33–5	23–0	83–0	1/17 in. × 2½ in. × 7½ in.	3. 0×6	4 0×7 0	6 1	6 3	11 2	Yes	18 2	7 8	9 6	7·9

NOTE.—The two last are of Italian make and have special wheels with plates fastened round them.

TABLE II.—TECHNICAL PARTICULARS OF CERTAIN MECHANICAL TRANSPORT VEHICLES USED BY ALLIED AND ENEMY FORCES DURING THE WAR, 1914-1918: LORRIES AND CARS.

Make.	Type.	Engine.						Clutch.	Gear Ratios.					Frame Sections.	Road Wheels					If Fitted with Winding Drum.	Overall Dimensions.			Total Weight.	Remarks.
		No. of Cyls.	Bore and Stroke.	Fitted Gov'nr.	Lubrication.	Cubic Capacity.	Carburettor.		1st.	2nd.	3rd.	Top.	Reverse.		Front. Diameter by Width.	Rear. Diameter by Width.	Overall Track. Front.	Overall Track. Rear.	Wheel Base.		Extreme Lngth.	Width.	Hght.		
			in. in.			cub. in.											ft. in.	ft. in.	ft. in.					tons	
Opel No. 61,638 (lorry)	Rail type	4	4·31 × 6·0	Yes	Pump ..	351	Pallas ..	Cone ..	37–0	20–0	14–0	8–5	—	Channel. ½ in. × 2½ in. × 5½ in.	27 in. × 5·5 in.	30 in. × 5·5 in.	5 5	5 4	14 5½	No	22 3	6 4	6 6	—	—
Bussing No. 66,431 (lorry)	—	4	5·11 × 5·31	Yes	—	436	Bussing ..	Cone ..	48–0	24–0	12–0	9–0	50–0	Channel. $\frac{5}{16}$ in. × 2$\frac{5}{8}$ in. × 5$\frac{5}{8}$ in. (inside of chassis)	2 ft. 3 in. × 7 in. (6-in. tyre)	2 ft. 10 in. × 13½ in. (6-in. tyre, twin)	5 4	5 9	11 6	Yes	20 0	5 11	6 9	—	—
Durkoff No. 61,668 (lorry)	—	4	4·52 × 5·11	Yes	Splash ..	328	—	Cone ..	76–0	38–0	23–0	15–0	67–0	Channel. $\frac{7}{16}$ in. × 2$\frac{7}{16}$ in. × 7 in.	2 ft. 3 in. × 5 in. (4½-in. tyre)	3 ft. 4 in. × 4½ in.	5 7½	6 2½	14 4	No	20 4	6 4	7 0	4½	—
Daimler No. 61,636 (lorry)	—	4	—	Yes	Mechanical pump	—	—	Cone ..	80–5	41–5	—	—	88–0	Channel. $\frac{5}{8}$ in. × 2$\frac{5}{8}$ in. × 7$\frac{1}{8}$ in.	2 ft. 4 in. × 5½ in.	3 ft. × 11½ in.	5 6½	6 2	13 9	No	20 1	6 5½	7 0	—	Overhead valves.
Oux No. 61,738 (lorry)	L-D type	4	—	Yes	Mechanical pump	—	—	Cone ..	57–5	32–0	23–5	14–0	58–0	Channel. ½ in. × 2$\frac{5}{8}$ in. × 6½ in.	2 ft. 6 in. × 4 in.	2 ft. 9½ in. × 11$\frac{3}{4}$ in.	5 8½	6 4	13 6	No	21 0	6 6½	6 3	—	—
Mercedes No. 63,611 (car)	—	4	—	No	Forced ..	—	—	Cone ..	15–1	8–1	5·125–1	3·75–1	19·25–1	Channel. $\frac{5}{16}$ in. × 2$\frac{1}{8}$ in. × 5$\frac{1}{8}$ in.	2 ft. 10½ in. × 5$\frac{1}{16}$ in.	2 ft. 10½ in. × 5$\frac{1}{16}$ in.	4 10	4 10	10 8	No	14 6	5 7	5 9	—	—
Wanderer No. 63,667 (car)	—	4	—	No	Mechanical pump	—	—	Cone ..	19–0	9–5	5–0	—	27–0	Channel. $\frac{5}{16}$ in. × 1$\frac{1}{16}$ in. × 2$\frac{3}{4}$ in.	2 ft. × 3 ft. (Will take 2 ft. 6 in. × 3½ in. tyres)	2 ft. × 3 ft.	3 9	3 9	7 10	No	10 8	4 0	—	—	—
Adler No. 60,358 (lorry)	—	4	—	Yes	Forced ..	—	—	Cone (leather covered)	61–50	38–0	24–0	13–50	80–0	Channel. ½ in. × 4 in. × 5½ in.	2 ft. 6 in. × 5½ in.	3 ft. 3$\frac{3}{4}$ in. × 4$\frac{3}{4}$ in. (Measurements 33 in. × 12 in.)	5 7½	6 7	13 7½	No	20 2	6 8½	6 6	—	—
Benz No. 63,631 (car)	Rail type	4	—	—	Forced ..	—	—	Cone (leather covered)	12–75	6–5	4–5	3–0	13–0	Channel. ½ in. × 1½ in. × 2$\frac{3}{4}$ in.	2 ft. 5$\frac{3}{4}$ in. × 5½ in.	2 ft. 5$\frac{3}{4}$ in. × 5½ in.	5 4	5 4	9 10	No	13 6	5 4	5 9	—	—
Benz No. 64,100 (car)	—	4	—	No	Mechanical pump	—	—	Cone (leather covered)	14–0	7–25	5–0	3–25	14–0	Channel. $\frac{5}{12}$ in. × 2$\frac{3}{4}$ in. 4$\frac{1}{16}$ in.	2 ft. 10$\frac{3}{4}$ in. × 4$\frac{3}{4}$ in.	2 ft. 10$\frac{3}{4}$ in. × 5$\frac{1}{16}$ in.	4 10	4 10	10 11	No	15 1½	5 10	5 0	—	—
F.I.A.T No. 61,689 (lorry)	—	4	—	Yes	Forced feed	—	—	Metal disc	33–32	28–56	16–04	9–52	25–0	Channel. $\frac{7}{12}$ in. × 2$\frac{3}{4}$ in. × 5½ in.	2 ft. 5½ in. × 5 in.	2 ft. 5½ in. × 5 in. (twin tyre)	5 11	6 3	12 0	No	18 7	6 5	—	—	—
Hansa Lloyd No. 61,633 (lorry)	22–50 h.p. P.S. 50	4	4·33 × 5·9	Yes	Forced feed	350	—	Cone ..	51·3	23–9	11–34	9–0	103–0	Channel. $\frac{5}{16}$ in. × 2$\frac{3}{4}$ in. × 5½ in.	3 ft. 1$\frac{1}{2}$ in. × 4 in.	3 ft. 4 in. × 4½ × 2 in.	5 4	5 9	13 2	No	21 0	6 6	9 0	—	Load platforms, 12 ft. 3 in. × 6 ft. 6 in.
Mulag No. 61,674 (lorry)	—	4	4·92 × 5·51	Yes	Forced feed	420	Zenith exhaust heated	Cone 17 in.	61–38	31–26	19–55	11–9	61–82	Channel. $\frac{5}{16}$ in. × 2$\frac{3}{4}$ in. × 5$\frac{1}{2}$ in.	3 ft. 0$\frac{3}{4}$ in. × 4$\frac{1}{2}$ in.	3 ft. 4$\frac{1}{2}$ in. × 4$\frac{1}{2}$ × 2 in.	6 3	6 3½	13 0	No	20 9	6 3	8 6	—	Load platform, 11 ft. 8 in. × 6 ft.
Stoewer No. 61,606 (lorry)	—	4	—	Yes	Pump ..	—	—	Cone ..	47–0	20–75	12–25	7–75	40–0	Channel. ½ in. × 3½ in. × 6½ in.	3 ft. 2 in. × 4 in.	3 ft. 5 in. × 5 in.	5 8	6 0	13 11	No	20 6	6 6	9 6	4·20	—
N.A.G. No. 66,416 (lorry)	40–45 h.p.	4	—	Yes	Pump ..	—	Pallas gravity feed	Cone ..	43–25	23–07	13–35	7–69	—	$\frac{7}{16}$ in. × 4 in. × 6½ in.	3 ft. 0½ in. × 4 in.	3 ft. 11½ in. × 4$\frac{3}{4}$ in.	5 8	6 2½	15 3	No	22 8	6 3	8 6	4·35	Load platform, 13 ft. 6 in. × 6 ft.
Benz No. 61,634 (lorry)	—	4	4·12 × 5·90	Yes	Pump ..	326	Pallas ..	Multi-disc	48–0	37–0	24–0	15–5	74–1	½ in. × 2 in. × 5$\frac{3}{4}$ in.	2 ft. 9 in. × 4 in.	3 ft. 4 in. × 5½ in.	5 8	6 0	14 2	No	21 6	6 3	8 9	3·85	Load platform, 13 ft. 3 in. × 6 ft. 3 in.
Opel No. 66,398 (lorry)	—	4	4·3 × 6·0	Yes	Pump and trough	350	Pallas ..	Cone ..	72–0	35–0	24–0	15–0	60–0	Channel. 2½ in. × $\frac{5}{16}$ in. × 5½ in.	3 ft. 0$\frac{3}{4}$ in. × 4$\frac{3}{4}$ in.	3 ft. 3$\frac{3}{4}$ in. × 4$\frac{3}{4}$ in. × 2 in.	5 7	6 0	14 4	No	20 8	6 0	6 7	—	Load platform, 12 ft. × 6 ft.

each other in the centre of the length of the machine. There is a large radiator, both in front and behind the engines. The engines drive through shafts to two gear-boxes which are, however, contained in a single casting. The final drive is by bevel and then spur-gear to the shafts of the sprocket wheels. The track plates and links are very much like the Holt, but the track is the whole length of the vehicle, and is carried on four short bogies each side, each bogie having five track rollers. The engine has overhead valves in water-cooled cages. As mentioned, this chassis was used to form a "Tank" by covering it with armour. The result was naturally a very inferior machine to ours, which were designed specially as fighting machines.

The lorries are of less interest than the tractors, but here also there are some points of note. The majority of the lorries are chain-driven, the chains being a good deal larger and more substantial than is usual here. One noticeable point is the gear ratios used. Lorries here usually have a gear ratio of from 6½ to 8 on their top speed, according to circumstances. The German lorries, however, are geared much lower, some having a top gear ratio of 14 or 15. This is no doubt due to the fact that rubber tyres were not available, and, therefore, the speed had to be very slow.

The usual tyre is steel with a wood packing about 2 in. thick between it and a cast-steel wheel. In some cases pads, apparently of rubber or rubber substitutes, are placed between the steel tyre and the wheel centre. Frames are of pressed steel, usually not so deep in section as ours, but with wider flanges. In some cases they are trussed. The objection to this is that it makes the frame very rigid vertically, and the Mulag has, accordingly, spiral springs in the struts to the tie-rod. Springs are long and often have very neat spiral spring shock-absorbers built into the dumb irons.

The front axles, in some cases, have exceptionally wide jaws and the bushes of the swivel pins are in the jaws, giving a wide base and low pressures. The ball joints of the steering-gear are very well enclosed, and have felt washers to keep the dirt out. As a result frames, springs and steering-joints appear to have given a great deal less trouble than the majority of ours.

In the majority of the chain-driven lorries the differential is not combined with the gear-box. In some cases this appears to be due to using a gear-box originally arranged for live-axle drive. Lubrication of shackles and small parts, both in the tractors and lorries, is often by very convenient oil-cups with ordinary syphon wick lubricators.

Radiators, both on the tractors and lorries, are often built up in sections of about 30 to 40 tubes, each section being bolted to the top and bottom header. The ends into which the tubes are fixed are made of steel pressings. There are many advantages in this, as each section can be renewed separately. Most of the radiators are entirely of steel or iron.

The light cars have no points of interest, except in two cases. One car is fitted with flanged wheels to run on a railway, and has underneath it a turntable on which it can be jacked up by hand and turned round to run the other way. The Wanderer light car is of interest from the fact that it appears to be a good deal lighter than the ordinary "light car" as made in this country. There is no body on it now, but when in use it had a two-seated body with the seats tandem, the steering being, therefore, in the centre.

Taking it all round, there is a great deal to be learnt from these vehicles, though there is much in design to avoid. Springs and frames, for instance, appear to have been more successful, as a rule, than ours, but axles, especially on the tractors, are in many cases too light, and gave trouble. There are many examples of how pressed steel can profitably be used, especially on details. The fixing of the dumb irons to the frames also appears to be excellent, whereas many of our fixings gave trouble. On the other hand, the designs appear, in many cases, very unnecessarily complicated and elaborate pressings are used when a little thought could have made them much simpler. The frames of the lorries, for instance, are often very complicated, there being many pieces when a few would suffice. In fact, the great criticism one feels inclined to make all round is that the designs are very unnecessarily expensive to construct and unnecessary expense means waste of man-power, a serious matter in war.

It is understood that members of the Institute of Automobile Engineers have been invited to inspect these vehicles we have dealt with above, and it is to be hoped that many will avail themselves of this invitation.

NOTES.

The Calorific Standard for Town Gas Supplies.

The South Metropolitan Gas Company has an enviable record for practicalising progressive ideas. Under Sir George Livesey it was one of the first great public undertakings to establish a system of profit sharing, which was later on supplemented by the appointment of workmen directors. Its record on the purely technical side of its activities is equally good, and it is now taking a prominent part in the practical establishment of the calorific standard. Powers to substitute this standard for that based on the illuminative value have been secured by many gas companies, but in most cases at any rate the powers have so far remained dormant. Since Michaelmas last, however, the calorific value has been the legal standard for the South Metropolitan supplies. The gas referees have not as yet prescribed an officially recognised recording calorimeter but are prepared to instal and try at their testing stations any type which appears likely to be satisfactory. A prolonged observation of the behaviour of these instruments will be made and form the basis for prescribing an officially recognised recorder at some later date. In the meantime they propose to use the calorimeters already installed at the South Metropolitan testing stations. The calorific value fixed by the Company's Acts is 550 British thermal units per cubic ft.

A London Circular Railway.

In the *Times* of Tuesday last an account is given of a proposal made by Mr. Alexander Ross, M.Inst.C.E., for a circular railway round London. The idea is not a novel one, of course, and on one occasion before the war one scheme made a certain amount of headway. Mr. Ross thinks the moment opportune for raising the scheme afresh on a rather different footing. His idea is for a railway coinciding roughly with a 12-mile radius from Charing Cross, coupled up with all the main line systems entering London, and crossing the Thames at Kingston by a bridge, and at Purfleet by a tunnel. There is no doubt that such an addition to our system would materially reduce the present congestion in London itself, where, at the terminals, a great deal of sorting and cartage has to be done in connection with traffic which is destined for points beyond London itself. With good organisation much of this traffic might be prevented from entering London at all, and could be diverted over the circular railway to the system beyond over which it would ultimately have to continue its journey. This, of course, has been the object of previous schemes, but there is some reason for pressing the scheme now so that the necessary land might be earmarked for it, instead of being covered with buildings, either houses or factories. The length of Mr. Ross's line would run to about 85 miles, which for double track would, he thinks, cost now about £17,000,000. It would be comparatively expensive on account of the number of junctions and crossings, but on the other hand the radius chosen gives a comparatively cheap route so far as cost of land is concerned. Another suggestion has been made that the lower Thames crossing should be made at Tilbury and Gravesend instead of at Purfleet. This would have the advantage of tapping direct the traffic of the Tilbury Docks. As this place is likely to increase in importance, and proposals are afoot for improving the passenger and goods accommodation there, this would seem to be worth consideration. There is no object in entraining passengers from the landing stage and then taking them to Purfleet before running them off to the north or south lines over the circular system. This distribution could be better made by means of a tunnel at Tilbury itself. The same applies to freight to be distributed from the docks. The service from the provinces to the docks would be better performed if the circular line ran to them direct, and altogether there seems to be much in favour of the Tilbury suggestion and very little to be said for the crossing at Purfleet and Dartford, neither of which can compete with Tilbury in importance, nor have they the interchange of cross-river traffic which already exists at Tilbury, a traffic which would doubtless quickly expand to a considerable extent.

SPECIAL SLIDE-RULES.

To the Editor of Engineering.

Sir,—In your review of Mr. Jackson's book on the slide-rule on page 571 in the current number, you state, referring to special slide-rules, that when used occasionally it frequently takes longer to learn them afresh than to make the calculations on an ordinary rule by more complicated operations. As manufacturers of special slide-rules, we trust that you will kindly spare us a little space to enter a protest. We have certainly seen some special rules which, while reflecting great credit on their designers, are undoubtedly complicated.

We have, however, always aimed at extreme simplicity in our designs. We have several special rules which have been favourably reviewed in the press. They are all in the ordinary form, having one slider and one cursor only, and the short concise instructions given on the back are so simple that they can always be taken up at a moment's notice, while the results are given in an incomparably superior fashion.

Our helical-spring rule, for instance, at *one setting* gives a complete selection of coil-diameters and wire thicknesses, not in decimals as given by an ordinary rule, but in the L.S.G. or 1/32nd in., round or square, and the calculation for deflection is equally simple. Our internal-combustion engine rules give all the calculations relating to horse-power, M.E.P., revolutions per minute, bore, stroke, &c., in a similar simple and concise fashion.

Yours faithfully,

The Cavendish Press,
Cheam, Surrey. A. E. Harley-Mason.

COAL OUTPUT—PAYMENT BASIS.

To the Editor of Engineering.

Sir,—One of the miners' objections to this was that the owners might not do their share in the efficient provision of means for output. Engineers, even though operating under mine managers, are responsible for the design, installation, running maintenance and the general efficiency of the mine equipment.

The attention of the owners is here drawn to the need for their engineers being on the National and District Committees to be set up for the purpose of securing co-operation between the owners and miners in maintaining their pledges to obtain increased output under clause 5 of the agreement reached. It is no less important that the miners should secure this.

It would seem to be the only means to ensure complete co-operation, viz., that these committees should comprise the coal-getter, the owner and the responsible operating engineer.

Yours faithfully,
H. J. Ping.

Power Alcohol in Hawaii.—United States Consular reports record progress in the production of alcohol from molasses and the waste from the canneries of pineapples. The process adopted is the Foster process, and as there are about 150,000 tons of molasses available per year, the Sandwich Islands should be able to rely on this source of power alcohol without having to import gasoline.

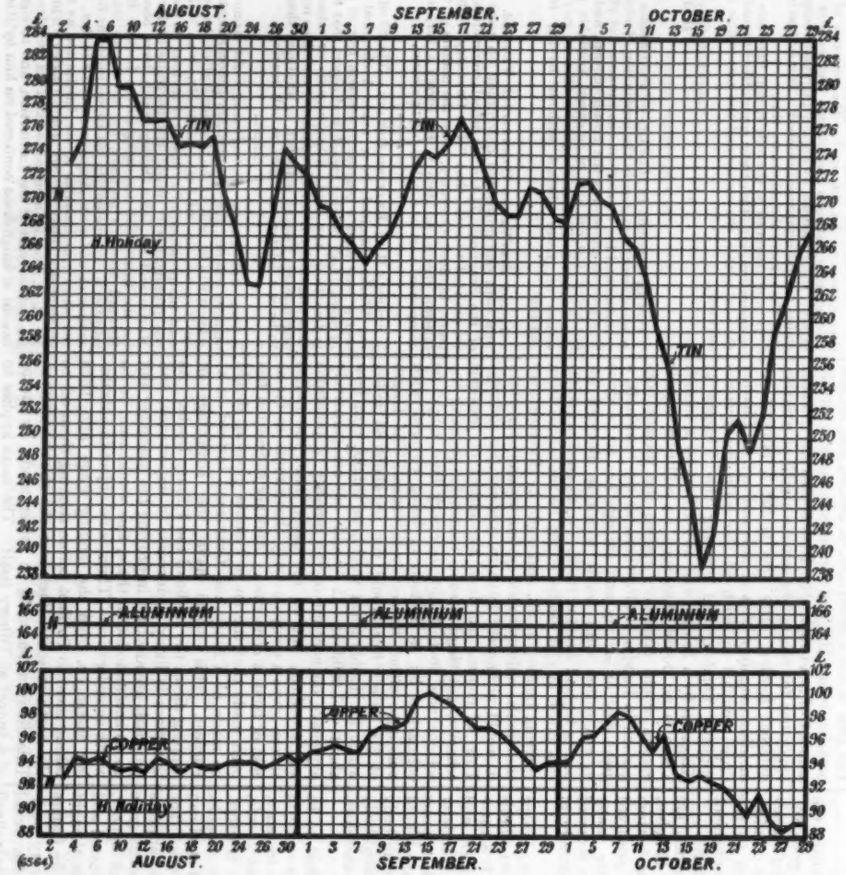
7½-ton Six-Wheel Commercial Vehicle. Addendum.—In our illustrated description on page 518 *ante* of the Scammell 7½-ton six-wheel commercial vehicle, we omitted to state that "The Coventry" Chain Company, Limited, Coventry, were the makers of the transmission chains, an item which forms a very important component part of a vehicle of this class.

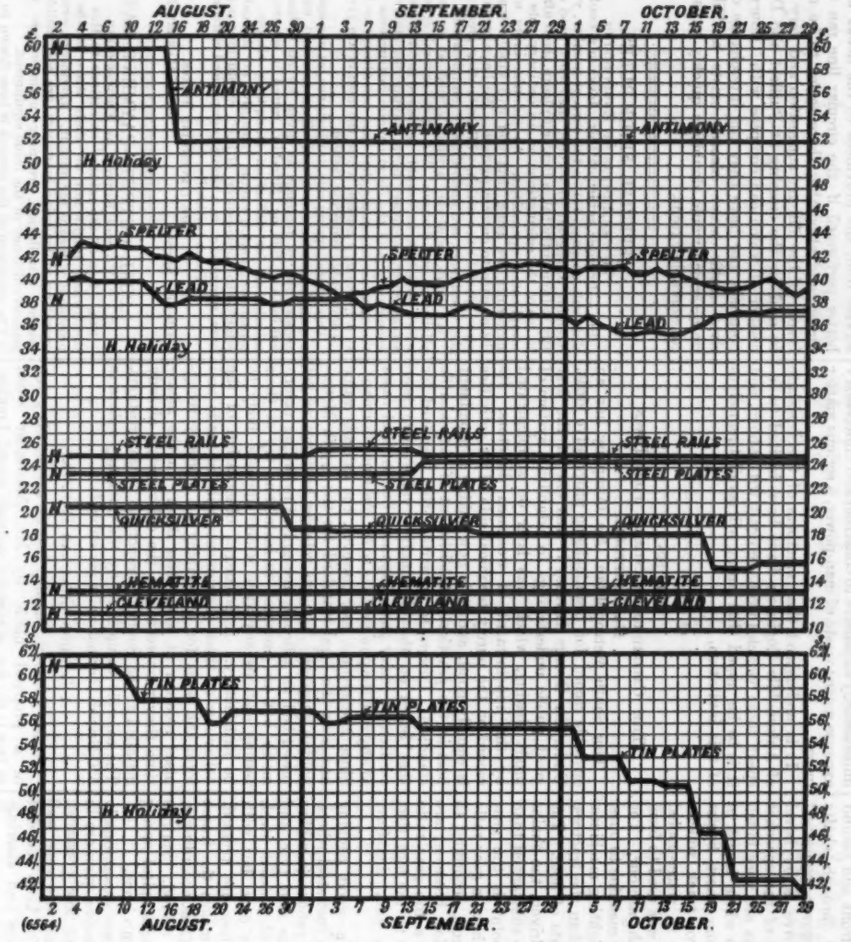
Stern's Ball-Bearing Grease.—The Sheffield Testing Works, Limited, have made a chemical analysis, and a four week's practical corrosion test of a sample of Sternol ball bearing grease, and report that the grease is free from any acid, either organic or mineral acid; it is practically free from moisture, and does not contain any mineral loading material, or anything that is likely to have a deleterious effect on ball bearings.

The Surveyors' Institution.—As announced in another column, the first ordinary general meeting of the session will be held in the Lecture Hall of the Institution on Monday, the 8th inst., when Mr. John Willmot will read his presidential address. Previous to the meeting the president will unveil the portraits of Mr. Howard Martin and Sir John Oakley which have been painted for the Institution and hung in the Lecture Hall. Mr. Howard Martin's portrait, by Mr. Lance Calkin, was painted to commemorate his appointment as first official arbitrator under the Acquisition of Land Act, 1919, and his many years' service to the Institution as a Member of Council. That of Sir John Oakley, which is by Mr. R. G. Eves, is intended to mark his presidency during the jubilee year of the Institution, and to signalise the honour of knighthood conferred on him by His Majesty

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)





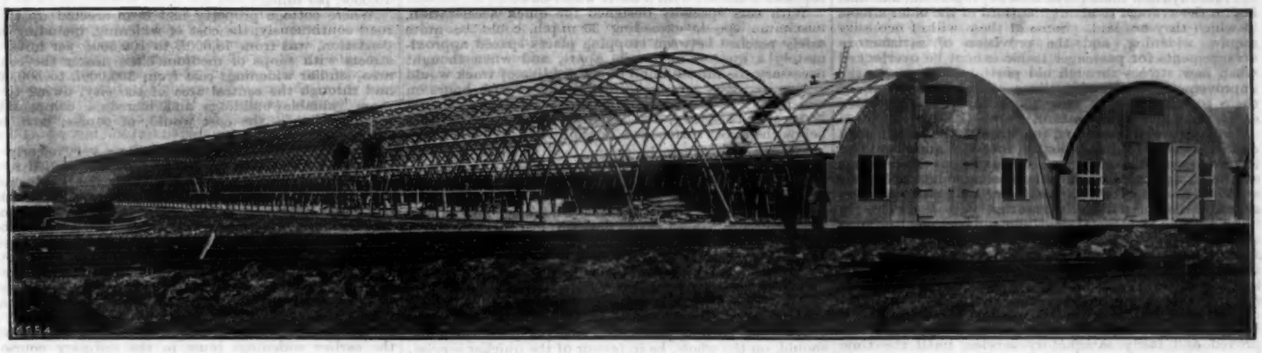
NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin plates, where they represent 1*s.* each.

MOTOR CARS IN SOUTH AFRICA.—A correspondent sends to *The South African Mining and Engineering Journal* the following official statement showing the number and value of motor cars imported into the Union of South Africa during the month of July, 1920. The United States contributes some 75 per cent. of the whole; United Kingdom, 22 per cent. of a value of 12,215*l.*; Canada, 196, value 34,771*l.*; France, 1, value 202*l.*; Italy, 1, value 290*l.*; United States of America, 749, value 243,634*l.*; total, 969, value 291,112*l.*

APPOINTMENT OF MARINE SURVEYORS AND EXAMINERS.—An examination for four appointments as engineer and ship surveyor, one appointment as ship surveyor and three appointments as nautical surveyor, will be held in London on Tuesday, January 11, 1921, and following days. One appointment as examiner of masters and mates will also be made (through the examination for nautical surveyors) if a candidate is found qualified for this post. Any person desiring appointment must apply on a special application form, which may be obtained from the Assistant Secretary, Marine Department, Board of Trade, Great George-street, S.W. 1. The list of candidates will be closed on December 2, 1920.

BRAZILIAN COTTON AND IRON AND MANGANESE ORE.—The possibility of Great Britain becoming a large purchaser of Brazilian cotton is arousing great interest in Brazil, according to the British Chamber of Commerce at Rio de Janeiro. The problem is mainly one of method of cultivation and goodwill between the two countries—on the part of Brazil to promote better production, easy conditions of export and favourable competitive prices; on the part of England to exercise patience until existing disadvantages are overcome. Brazil can no doubt become a great cotton-producing country, and she promises iron ore in practically inexhaustible quantities. If England will establish herself as the largest importer of these two Brazilian exports, she will stake out a claim to a large share of Brazilian trade which is no doubt destined to increase in importance year by year and which no large foreign trading country can afford to neglect. Moreover, Brazil possesses some of the richest manganese ore deposits in the world, with transport facilities for shipment at Rio. The development of Brazilian manganese ore export therefore offers another excellent field for British enterprise and capital.

TEN ACRE NISSEN BUILDING.



A LARGE depot to be used for the storage of wool is approaching completion at Hull by Messrs. Nissens, Limited, of 174, Corporation-street, Birmingham, for the Ministry of Munitions. The area covered by this building is approximately ten acres, and construction was commenced only on the 16th of June last. The type of building selected is a development of the well-known Nissen hut, which proved its practical utility on a wide scale so successfully during the war. The depot consists of 18 buildings of the Nissen type, each 552 ft. long by 40 ft. wide, all communicating.

Our illustration herewith shows the three last bays under erection. The speed with which this job has been executed has been possible mainly, of course, on account of the simplicity of this form of construction. Only 40 men, on piece-work, have been employed, and the rate of building has been approximately one bay of 552 ft. completed per week, which is an extremely creditable record. Nothing more elaborate is needed in the erection than a common derrick mast. Each semi-circular rib is made up of five segments, joined by fishplates. These ribs are held together by wood purlins of a universal pattern. The buildings are double-skinned with an air space of 7 in. between the inner and outer linings of galvanised corrugated sheet. The buildings are thus damp-proof, and are not affected by condensation. Gutter troughs are arranged in the valleys between contiguous bays.

The lighting is by two rows of patent glazing facing north, carried on lead-covered steel bars. The end panels have been built of wood, but are, of course, commonly made of brick or concrete block, &c. This form of construction has several advantages, and is suitable for many purposes. As the ribs are 5 ft. apart, buildings of practically any length can be made. They are absolutely weather-proof, are capable of erection by unskilled labour, and if lined with 2-in. plaster slabs will be found as cool as brick buildings.

THE INSTITUTION OF CIVIL ENGINEERS.

Presidential Address of* JOHN ALEXANDER BRODIE.

GENTLEMEN, I have to thank the members of the Institution for electing me to the presidential chair. While appreciating from the personal point of view the honour of election, I feel that I am to look upon it also as a recognition of the importance of the branch of the profession to which I more especially belong, that of Municipal and County Engineers, who now form a very numerous body, and of whom a large and increasing proportion are members of this Institution. It will be difficult for me to fill the position so ably occupied by my friend Sir John Purser Griffith, the most recent of a long line of distinguished presidents, but being assured of the support and friendly help of the Council, the secretary and members, I trust that I shall carry out the duties to your satisfaction and with due regard to the great interests of the Institution and the engineering profession generally.

It has, I think, been customary for the president to take as the subject of his address some of the matters coming within his own exprience, and I propose, as the main portion of the remarks I have to make, to offer certain observations on the engineering matters which affect the proper planning and development of the larger towns and their surroundings, and on the means of communication and facilities for local transport and general traffic. In the first place, however, I propose to say a few words on the training of young engineers who intend to enter the municipal branch of the profession. These indeed may be taken to represent the result of my experience and observation of the training of those engineers who propose to devote a considerable portion of their lives to the carrying out and supervision of important works.

In my opinion it is very important that the young engineer should, at an early stage of his training, have a period of workshop and outside works experience in some of the branches of engineering which involve the use of constructional materials of various classes. Not only does he thus learn in a thorough manner the qualities of materials, the processes of their manipulation, and approved methods of carrying out work generally, but he has opportunities of coming in contact on an intimate and friendly footing with workmen. He thus learns to appreciate their point of view as well as the conditions under which they work. Such experience should assist him towards becoming a sound judge of character and enable him to pick out the right types of men for positions under him thereafter in connection with the design and execution of work.

While an advocate for practical training, I do not suggest that this should be at the expense of scientific education in these days. The wise young engineer will while giving due attention to practical work, take care that he does not allow his theoretical training to come to a standstill, or his general knowledge to rust. The test of knowledge furnished by the examinations of this Institution and of the Institution of Municipal and County Engineers should be undergone at an early age, and the certificates issued by these bodies obtained.

If men are to be fully trained and competent, they should be adequately paid. It cannot, I think, be said that satisfactory rates of remuneration are paid to the younger members of the profession generally, particularly to the holders of the smaller public engineering positions throughout the country. Most of us who have had to do with the training and advising of young engineers know that a great many of the most promising young professional men go abroad, openings with reasonable remuneration and prospects of advancement being difficult to find at home. Many fully-trained and competent young engineers are also lost to the profession, because they find it necessary to take up other lines of business in which a more liberal remuneration for the present and prospect of provision for the future can be more readily assured.

Affecting, as it does, the retention or otherwise in this country, of the most capable and energetic of the younger professional men, the question of remuneration requires attention, especially when a comparison is made with the payment to young workmen of various grades, many of whom do not care to make use of opportunities for improvement, and who at the end of their day's work lay down their tools and do not trouble further about their work.

Method of Town Development.—In this country most of the larger cities originated long ago as villages or clusters of houses surrounding strong points, becoming in course of time small towns and gradually enlarging until they reached their present importance. In recent times particularly, the increase in the area and number of inhabitants of the larger centres of population has been great. It is not to be wondered at, therefore, that the arrangement of their streets has been, and is still found in many cases, very ill-suited for the conditions of to-day.

In a typical case the parish boundary formed the limit of area under the control of the original authority. When the population has overflowed the boundary sufficiently into the district of the small adjoining authority, the latter has been absorbed. In the ordinary procedure the newly incorporated areas are found to have been laid out on unsuitable lines for forming part of a larger town, and much of the work, particularly in connection with the improvement of main roads, already done once, has, after incorporation, to be done over again at great expense. In some cases this overflow and enlargement of boundaries has been repeated several times.

As this wasteful procedure has been the rule and not the exception, it might be expected that something in the nature of a sound general policy would, in the course of time, have been developed, but there is little evidence of this, and even during the past session in Parliament, after costly enquiries, one notable city, probably quite rightly, has been allowed to absorb large adjoining areas including a neighbouring borough, whilst important towns, the development of which on proper lines should be fostered and helped on broad national grounds, are refused the inclusion of areas which must clearly form parts of these towns in the future.

The 1909 Town Planning Act, although cumbersome in procedure, was an important step in the direction of enabling outside areas to be developed on suitable lines, but the great cost of carrying out street and other works on a proper scale is the stumbling block which will probably prevent much being done unless monetary help is provided either by the Government departments or by the large centre of population adjoining, whose interest and duty it should be to see that proper development takes place, in the first instance.

The recent policy of the hurried erection of large numbers of cottages for the working classes, whilst little or nothing is being done in providing for the erection of larger houses or buildings of a more important appearance, is likely to have the effect of superseding the more orderly planning, and of spoiling the effect of the wider roads, where these have been adopted. The provision of satisfactory arterial roads is not in many cases being sufficiently attended to, and unless greater care is taken to safeguard main lines of communication, it will, in some cases, be difficult for residents to reach their houses in outlying areas within any reasonable time.

It is certainly remarkable that in this country the large and really essential matters on which the trade and prosperity of great towns depend do not receive so much care and attention as the smaller local requirements which are clearly a duty laid upon the various local authorities.

The fact remains that neither at the centre of government nor locally does there exist in this country any individual or body whose duty it is to co-ordinate the various separate and completely independent local authorities surrounding important town centres, so that orderly development and continuity of policy in the larger matters can be insisted upon; and no effectual means appear to exist (other than absorption of such areas by the adjoining larger authority), of inducing them to sink small local differences, and to act together in the greater interests of the trading centre of which they in reality form part, or even to safeguard the greater national interests which some of them represent.

It may be said that these are matters of policy and not matters for engineers. It was similarly stated in the early stages that the war was entirely a matter for the military authorities, and not for engineers, and it was only after serious and costly failures that the services of competent engineers with experience in particular classes of work were more fully utilised. In my opinion engineers have been much too easy going in these and other matters where inexperienced and unsuitably trained men have, perhaps, on that account been more pushful.

Waves of enthusiasm in connection with town planning and housing have done a great deal of good by directing the attention of municipal engineers, surveyors, architects, builders and others, to the various problems connected with the proper planning and development of towns, and much has been done by conferences and lectures to broaden the view of public representatives on councils and committees.

It appears to be thought that good schemes for the development of a town can be obtained as the result of a short survey by experts, followed by the preparation of a report and the submission of effectively prepared plans; and though such a procedure may be helpful in some cases, it is hardly likely that many of the more serious problems can be satisfactorily solved by anyone not intimately acquainted with the general trend of development, and with the conditions affecting adjoining areas.

The real spadework of town development will no doubt continue to devolve on the municipal engineer, whose duty it generally is to advise from day to day and to deal with the engineering problems which lie at the root of the satisfactory planning and replanning of town areas, and who usually has the intimate knowledge of all local matters likely to affect the proper treatment of the area coming under his control.

Facilities for Local Passenger Transit.—To provide for local passenger movement has always been one of the most important functions of street surfaces in our towns, and statistics recently quoted before this Institution show that street surface methods of passenger conveyance continue to deal with an increasing proportion of all passengers using public conveyances in London, notwithstanding the various competing types and

* Delivered at the Institution, November 2, 1920.

methods of passenger transit which have been introduced; and the same thing applies and is likely to hold good for most other large centres of population in this country.

Tramways now monopolise a large proportion, amounting on the average to about one-third of the older streets in which they are laid. Some of these will of necessity require widening, and the provision of satisfactory arrangements for passenger traffic cannot be overlooked when new streets through old portions of a town, the improvement of the older lines of communication, or their continuation as new roads through developing areas, are under consideration.

It may be well, therefore, to glance at the past history and to look into the probable future requirements of local passenger conveyance, especially as large sums are being expended on housing accommodation for the working classes in the larger towns and cities at considerable distances from their work.

As soon as residential development had reached such a distance from the centre as to make the time lost in walking, between the home and business, a matter of importance, horse omnibuses were generally brought into use.

In many cases, after 1860, when tramways were first constructed in Birkenhead, the omnibus was replaced by the horse-drawn tramway-car, which gave an improved and fairly satisfactory service, until the time lost reached about 30 minutes. The faster electric tramway service was introduced some twenty years ago, and in many cases both the cars and the track laid for them are now reaching the approximate limit of their useful life, and large expenditures are likely to be necessary for reconstruction and re-equipment if the system, as it at present exists, is to remain in use.

It is, however, hardly likely that existing speeds and road conditions will meet the traffic requirements of the next twenty or twenty-five years, which may be taken as the new life of the reconstructed track, and it is necessary, therefore, that care should be exercised and the new conditions understood before these expenditures are incurred, particularly for routes covering the longer distances, if satisfactory services are to be obtained. Where the total length of journey does not involve a longer time than 25 minutes under present conditions, the total saving of time obtainable from greater speeds is not of so much importance.

Competitive electric train systems have been introduced, the best stopping trains with stations about a mile apart, giving an average speed of from 20 m.p.h. to 25 m.p.h., or approximately equal to three times the average electric tramway speed along narrow streets. Passengers are thus being carried to distances of from 6 miles to 20 miles away from the centre, whilst areas ready for development, in some cases with streets and sewers already constructed, within three miles or four miles from the business centres, but which cannot be reached by present tramway services in the same time, are left without buildings.

In a case which has come under my observation one of the effects appears to be that the increase in population of the parent city with plenty of open ground available has been much retarded, and the growth of population in the outside areas correspondingly quickened, whilst the general rate of increase of the population surrounding the centre as a whole has remained fairly constant. The total loss of population to the city area in this case, at the date of the last census, had reached approximately 150,000.

The whole of this loss may not be properly attributable to means of communication, but it will be seen that the question of improved means of local passenger service in the larger towns is one of essential importance, requiring the serious consideration of municipal engineers responsible for the provision of new streets as well as of those responsible for operating the surface carrying systems of our great towns. Though attempts to speed up have been made, the safety of the other users of our present narrow roads has prevented much improvement in this direction.

The introduction of the motor-omnibus has in some cases resulted in a quicker service, but unfortunately it has been found that in actual work the cost per car-mile of operating motor-omnibuses, when all charges are included, exceeds the similar cost on the overhead wire electric tramway, whilst the cost per seat-mile of omnibuses, as shown in published figures, exceeded the cost per seat-mile in tramcars by 114 per cent.

No doubt improvements in the carrying capacity of motor-buses may reduce the relative cost per seat-mile, but the inherent difficulty of safely steering very large motor-buses at high average speeds in narrow and crowded streets will probably prevent the ordinary tramcar figures being reached, and it is probable that the tramway vehicle itself is capable of even greater relative improvement than the motor-bus.

On the whole, it appears likely that the balance of advantage will remain with the tramway or guided type of vehicle, wherever large numbers of passengers are to be carried along a route where conditions are such as to permit of improved acceleration, high average speeds, and the best results obtainable from both types of vehicles.

To put road passenger services on a proper footing municipal engineers, and others interested, will, however, have to provide roads suitable for high average speeds, whilst tramcar builders will have to re-design their vehicles and adopt some of the good points in motor-bus construction, which tramcars at present lack.

Great improvements both in speed and comfort can be introduced on surface tramways in wide roads under special conditions. I may cite an instance where the rails are laid on wooden sleepers on a clinker foundation, the upper surface within the limits of the track being finished in grass, and a low fence or hedge provided on each side to keep off stray animals. Speeds up to 20 m.p.h. have been authorised by the Board of Trade and are being run quite safely, and tests show much higher maximum speeds, whilst still using the old-fashioned top-seat tramcars with a short wheel-base.

With cars specially designed for quick acceleration, maximum speeds exceeding 30 m.p.h. could be quite safely reached between stopping places spaced approximately a quarter of a mile apart, and when thought necessary the introduction of a third line of track would enable non-stop cars to be introduced at rush hours on which high average speeds could be attained. Should it become necessary, the construction of express lines below the street surface is a possibility.

Whether fences can be maintained when the land on each side is fully developed for residences and shops remains to be seen, but it is probable that the advantage of the quick and safe transit, which can be so provided, will outweigh the disadvantages of fencing, and in any case the fence can be easily lowered, or otherwise made to meet requirements, should such a course become necessary.

At least double the mileage can be obtained on such a line from the car, the driver and the conductor, as compared with the tramway laid on the narrower street surface, and though the current consumption will be greater, the earning power and cost per passenger-mile, should, on the whole, be in favour of the quicker service. It is also found that the running of the cars on such a line is very much quieter than on the more rigid and paved track usually laid. Great improvement in quietness of running would result from the adoption of a resilient tyre in place of the steel tyre at present in use, and if, in addition, the very best mechanical arrangements are adopted for the transmission of power in the car there does not appear to be any good reason why public tramway vehicles should not be as quiet in running as private motor cars.

The saving in wear of the rail surface, and the additional life of track so obtainable, is also likely to be of greater importance in the future as the cost of ordinary track construction is at present approximately three times that of similar work in pre-war times.

The additional comfort of such a vehicle to the passenger, combined with the absence of jarring noises to the frontagers resident on each side of the track, would more than warrant its adoption. On the whole, the time appears to be ripe for the introduction of radical improvements in connection with the longer distance systems of tramway transport.

The question how far such a method of construction can be carried down through the already built up portions of the larger towns is one which requires careful consideration. If fast services are to be given, it will be necessary in any case to have special tracks, and experience leads me to think that in most cases an improved and widened street surface, if judiciously chosen, will be both cheaper and more advantageous to town residents and to passengers than anything in the nature of underground work, the cost of which has in the past been so heavy as to prohibit the paying of dividends on capital expenditure in any but the very large cities.

Where the total population to be carried will not warrant the necessary heavy expenditure on underground tunnels, and where overhead railways do not find favour, it is likely that a limited number of fast surface lines, constructed on wide roads through the more densely populated districts branching out fan-like into the outer area now being developed, could be made to compete successfully, both in time, cost of working and general convenience, with any other system at present in sight for distances of from three miles to eight miles from the centre of a city.

A point of much importance, which is generally overlooked by municipalities and by ratepayers owning and operating tramway passenger systems, on whom the cost of road widenings largely necessitated by tramway traffic falls somewhat heavily, and one which they should carefully consider, is the advantage obtainable from applying a proportion of the tramway earnings directly towards reducing the cost of street widenings, which, in turn, will enable quicker, more efficient and more economical tramway services to be given.

If, for example, it could be arranged that a sum of 1,000*l.* per mile of single track (a not uncommon net profit in pre-war days) could be contributed as, say, one-third of an annual expenditure on street improvements, the other two-thirds being equally divided between the street authority out of the local rates and the Central Road Authority, out of national funds, the improvement of existing main thoroughfares leading into or out of our towns could be systematically tackled, and something could be done each year toward expenditures which are becoming increasingly necessary, but which are being generally postponed from time to time in a rather short-sighted way.

Such an arrangement should be looked upon favourably both by the street authority and by the tramway undertaking, who do not always see eye to eye on road matters, and also by the Central Road Authority, who should be anxious to see road improvements quickly carried out in the interests of general traffic.

Main Roads in Towns.—The introduction of horse tramways by companies as a means of conveying local passengers, and the construction in many places of single line and passing places—thus causing great inconvenience to the general users of the road—directed public attention to the necessity for street widening, and the subsequent introduction of the electric system of operation induced many authorities to spend large sums of money on street widenings, though these in most cases did not exceed a total width of 60 ft., whilst the great increase in road traffic by motor vehicles, combined with the necessity for improved passenger communication, is again causing a demand for further improvement in road facilities. Experience has shown that in pre-war times roads 80 ft. in width, with 24-ft. carriage-ways and narrow foot-ways could, through cheap land, be constructed at an average cost of about 10,000*l.* per mile.

Where cottage property had been erected up to the road continuously, the cost of widening, including compensation, was from 70,000*l.* to 100,000*l.* per mile. In streets with shops of medium class nearer the central area, similar widenings cost from 350,000*l.* to 500,000*l.*, and through the central area of the city, owing to the more valuable buildings and increased compensation for disturbance, the cost would, of course, have been much greater.

Typical figures such as these show very clearly the advantage and economy of foresight, as applied to the construction of main approach roads in the first instance. A good example of the advance of public opinion in these matters is shown in the case of a short length of main thoroughfare, the first portion of which was, about twenty years ago, widened from 40 ft. to 60 ft., a second length from 40 ft. to 70 ft., a later length to 90 ft., another still later to 114 ft., whilst the projected width of another length, in which valuable trees should be saved, is to a minimum of 150 ft. All these samples of width can be seen in one continuous portion of an approach road not exceeding half a mile in length, and inevitably some of the earlier widenings must in the ordinary course of events be again widened, or, alternatively, another route must be found to meet the requirements of the faster traffic now necessary, and to enable the outlying building lands to be advantageously used as housing areas.

As the result of experience, my authority has adopted 120 ft. between street fences as a standard minimum width for main arterial roads through the unbuilt outskirts, the main building line being set back 12 ft. from the fences, making a total width between buildings of 144 ft. One great advantage of providing ample width at first when land is cheap is that provision can at any time be made for express services either on the surface by additional lines, or just below the surface in cases where such an extra cost would be warranted by subsequent traffic due to increase in population. The best arrangement of street surface to meet the requirements of traffic in wide streets has received a great deal of attention, and many types have been tried.

A section at one time favoured and used in some places on the Continent placed lines of tramway on each side of the road close to the footpaths; and in cases where side streets, having the right of entrance to the main carriage-way, are few and far between, or where, as in the case of the Thames Embankment, the traffic from side streets comes in on one side only, leaving the other side unbroken, the placing of tramways on that side can be recommended.

On the average main road side entrances must usually be provided for, and the consequent interference with the traffic, combined with the necessity for giving access from the roadway to the houses or shops direct, has induced most engineers to favour the placing of the tramways in the middle, though in this position it may be somewhat more inconvenient for the passengers when boarding or leaving a car.

Observation on a wide street with a boulevard or walk in the centre, and having a carriage-way on either side, shows that whilst the slower horse traffic usually follows one of the roads in both directions, fast motor traffic, on the other hand, appears to use both roadways and hugs the kerb of the central promenade in both directions, keeping away as far as possible from the side streets, in this way avoiding the interference with speed and the additional risk of collision which arises owing to vehicles coming in carelessly from the side streets when joining or crossing the main stream of traffic.

The typical Liverpool road of 120 ft. or more in width has in the centre a double line of tramways finished, as already described, with a grass surface, the rails being laid on wooden sleepers with low privet side hedges separating this track from the carriage-ways, which are in duplicate, one on each side for traffic entering and leaving the town respectively, each road having a width of 24 ft. between kerbs, the balance of width, beyond the footpath requirement, being left in grass until additional width of carriage-way is required. Streets and avenues of greater width, which allow of boulevards or exercise spaces, are at present being constructed throughout areas now being developed for housing schemes, and in other cases where the provision of width for traffic would involve the destruction of fine trees. Trees, I may say, are now looked upon as a valuable feature, but even twenty years ago they would have been ruthlessly cut down for the erection of houses of the smallest type, at the rate of 40 or even 50 to the acre.

That the more enlightened policy in regard to wide main roads is not of isolated character is shown by the case of Birmingham where, after the fullest inquiry, the authority adopted the prescription of property lines to a width of 120 ft. on all the main approach roads to the centre of the city, and there is no doubt that many of the larger towns will ultimately follow this bold and statesmanlike view of the future requirements as affecting the best interests of the inhabitants. Leeds, Manchester, Dundee, and other towns have also such roads under consideration, and it can be safely assumed that when authorities understand and recognise the full benefit on public health and general grounds, of the lead in this matter, the policy will be more generally adopted.

Whilst very excellent work has been carried out and much valuable information obtained as to schemes for arterial roads through the London area, the Great Western Outlet road alone appears to be in the course of construction, and it is understood that the width of street has, in this case, been fixed at 80 ft.

It is to be hoped that before completion wiser counsels will prevail and that even if the roadway is for the present

to remain at 80 ft., care will be taken to keep back the front of buildings abutting on it to at least 75 ft. on each side of the centre line, so that when the additional width is needed for traffic and other purposes, which will probably be at no distant date, the full advantage of width and more effective treatment will still be obtainable.

Some engineers and other authorities, when discussing widths of roads, have been accustomed to look upon them as a means of providing for traffic requirements only, and in my view this is a serious error. As one who has had the opportunity of observing almost daily for over thirty years the use made of a roadway, somewhat exceeding 120 ft. in width, within the built-up portion of the City, I could not fail to recognise the very great value of such a space to the residents in the closely-housed areas on each side of it immediately behind the more imposing frontage residences.

Especially in the evenings after business hours, and during the winter months, when parks and recreation grounds are practically unlit and therefore not available, it is largely used as a promenade and exercise ground, and it is not too much to say that no other space provided by the public authority is more appreciated and used.

It is intended that roads of this character shall be laid out through the outer areas not yet developed at distances of approximately half mile apart, and with cross roads of the same class at distances of about one mile apart. It has been found by experience that in built-up portions of the town the main roads, carrying tramway traffic, are conveniently spaced at approximately these distances apart, and as the number of houses to the acre in the new outskirts is only one-third to one-quarter of what was the custom twenty-five years ago, whilst the tramway-riding habits of the people have increased during the same period six-fold, these distances appear likely to meet the requirements.

Secondary roads, averaging about 80 ft. in width, are intended, halving the distances between main streets in each direction, and in the case of the cross streets smaller secondary roads will again sub-divide the areas at about one quarter mile apart. It must not, however, be understood that anything in the nature of a chess-board pattern is to be adopted. Such a course would be impossible as well as undesirable in the outer areas of an old city, and due allowance must be made for the directions of the existing roads, the contours of the new districts and other conditions, which render a departure from hard and fast lines necessary

It is intended to leave a fairly free hand in the lay-out of the internal streets in the plots bounded by main and secondary roads. No portion should much exceed a walking distance of one quarter mile from the main road with its public passenger service, and, though the tendency of present-day authorities seems to favour right-angled turns, curves, and other features, which look well on plans, it is hoped that the general direction of pedestrians travelling out of the area will be towards the intersections of the main and secondary cross roads with the main radial road, at which points stopping places for the passenger vehicles are provided.

Through traffic of all sorts will find the easiest and most direct lines of travel to be by means of main and secondary roads, leaving the residential street largely undisturbed except by the purely internal traffic required by the residents within the area.

Under these conditions additional width in the main and secondary roads where required for through traffic can be provided without excessive cost, and it is intended to reduce the amount of land and street works to a minimum for the internal roads and so to reduce the average cost of laying out the whole area, whilst giving the width required for traffic purposes where it will be of the greatest public advantage.

Roads Outside Town Areas.—The improvement of existing roads outside town areas, and the provision of new roads to meet the requirements of increased modern traffic, have received a great deal of attention from responsible engineers, who are accustomed to look ahead, but few radical improvements have been carried out in this country, and practically no typical new main roads have been constructed.

Many of our roads are too narrow to permit of motor vehicles passing bulky loads, which are so prominent a feature in many country roads. Where the more permanent road materials are being laid it is also a great advantage to be able to construct one portion of the carriage-way whilst the remainder is used for the passage of ordinary traffic. It is probable, therefore, that no width of carriage-way less than 30 ft. will meet the requirements where any considerable amount of traffic is to be expected, and carriage-ways 36 ft. in width, with ample margins and separate footpaths, should in many cases be provided.

The time has probably arrived when the erection of any house or building immediately abutting on the side of any main road should be prohibited by law. The question of how far buildings should be kept back is important, but bearing in mind dust and noise, and the danger to children and domestic animals from passing traffic, the adoption of a universal building line for new erections not less than 60 ft. from the centre line of main roads is to be strongly recommended. The land lying between the house and the road need not, in most cases, be added to the road, but when the house is built to the new line, such land might be made use of as gardens; alternatively, the land could be utilised for ordinary agricultural purposes until required by traffic for road widening.

Another matter of considerable importance is the question of the improvement and maintenance of hedges and fences. Where additional width is necessary between fences, the Road Authority might be made responsible for the construction or planting of the new fence and for its subsequent maintenance. In this way suitably maintained road fences would ultimately become possible, to the great advantage of roads and road users, whilst the owners of the land would, in most cases, be glad to be relieved of this responsibility.

Such a general policy, if combined with the power to purchase land for widening, at the average value of the fields or other areas abutting on the road, would probably enable great improvements in the nature of straightening and widening to be carried out cheaply and quickly. If, with these measures, all curves were increased to a minimum radius suitable for fast traffic and were reasonably banked up on the outer side, another great step would have been taken towards genuine road improvement. At corners and intersections it is very necessary that sufficient open spaces, free from obstacles, should be left, with the object of enabling fast-moving vehicles to be safely manœuvred. Regulation is also required at intersections, and signs should be fixed clearly indicating which line of traffic should proceed and which should slow up. In one case at cross roads the difficulty has been solved by placing an island refuge with lamps in the road of minor traffic importance, so that it is now necessary for all vehicles using this road to slow up before crossing or entering the line of traffic.

Another matter of much importance is the question of the strength of road bridges and the responsibility for the upkeep of the road surface over them. This should in every case of an important road be maintained by the road authority if necessary at the cost of the company or other owner of the bridges. Companies and others who cling to supposed or other rights which are directly opposed to clearly defined public interests, will hardly change their views without pressure. It should be within the power of the Department of Transport to insist on a fair and equitable solution and to press for the prompt treatment of offending bridges. Obstruction to necessary public improvements has been so fully developed that there is much to be said for the principle of expropriation adopted by some of the Continental nations.

Trunk Roads for Heavy Transport.—When dealing with roads outside built-up areas some consideration should be given to the necessity for the construction of new trunk roads in this country, and there can, I think, be little doubt that a limited number of such roads should be laid out wherever the amount of traffic is likely to warrant their construction. The traffic between the manufacturing districts of Lancashire, and parts of Yorkshire, and the port of Liverpool may serve as an illustration. Prior to the war, motor traffic along the existing roads was increasing rapidly, and even at that time experienced gentlemen responsible for the conduct of motor traffic assured me that they would not object to paying 20*l.* per annum per motor vehicle provided that they could be assured of reasonably good roads between the manufacturing districts and Liverpool.

Traffic figures taken this year on the principal roads leading out to Lancashire, show that 12,000 tons per day, or, say, 3,500,000 tons per annum were passing to and fro, and this traffic is very rapidly increasing. The Lancashire County Surveyor has published traffic figures taken on a portion of the main road near Manchester, showing that traffic had increased 19½ times as compared with the tonnage of 1912, and no doubt other portions of routes between great centres could show figures in a somewhat similar proportion.

The construction of a main transport road, to meet the requirements of road traffic on a route of so much importance, would in itself be a great monument to the victory lately achieved, and it is to be hoped that well-thought-out schemes for work of national importance are in the pigeon-holes, so that they may be picked out and made use of in the near future should the necessity arise. It may be interesting to consider what the general features of such a road should now be, and how the surfaces should be arranged to meet the requirements of the various classes of traffic likely to make use of it when constructed. The surfaces should be capable of taking all the various types of land traffic at present

COST OF PAVEMENTS.

Pavement.	Traffic. Tons per Yard Width per Annum.	Life.		Pre-War.						1920.					
					Annual Charges.						Annual Charges.				
		Years.	Tons per Yard Width.	Cost per Sq. Yd.	Int. and S.F. at 3 per Cent.	Maintenance.	Cleansing.	Ton-Miles per Penny (excluding cleansing).	Cost per Ton-Mile	Cost per Sq. Yd.	Int. and S.F. at 6 per Cent.	Maintenance.	Cleansing.	Ton-Miles per Penny (excluding cleansing).	Cost per Ton-Mile
Surface.				*s. d.*	*d.*	*d.*	*d.*		*d.*	*s. d.*	*s. d.*	*s. d.*	*d.*		*d.*
6-in. setts	524,000	18	9,432,000	10 0	8½	—	3½	34·0	0·029	36 0	3 4	—	8	7·4	0·134
4-in. cube setts	150,000	50	7,500,000	7 6	3½	—	3½	24·4	0·041	31 6	2 0	—	8	3·5	0·28
Hardwood	162,000	17	2,754,000	13 6	12½	—	2½	7·4	0·136	Costs not available			8½	—	—
Softwood	204,000	18	3,672,000	8 6	7½	—	2½	15·5	0·064	46 6	4 4	—	8½	2·2	0·45
4-in. pitch macadam (hard stone)	120,000	20	2,400,000	4 0	3½	½	2½	19·5	0·051	12 6	1 1	0 1	4½	4·9	0·20
4-in. tarred slag macadam	120,000	15	1,800,000	4 0	4	1	2½	13·6	0·073	8 0	0 10	0 3	4½	5·2	0·19
1-in. Trinidad asphalt on 3-in. asphaltic concrete	120,000	15	1,800,000	7 6	7½	—	2½	9·1	0·11	18 6	1 11	—	4½	3·0	0·34
4-in. concrete coated with ½-in. pitch and chippings	120,000	20	2,400,000	2 9	2½	1	2½	20·9	0·048	8 6	0 9	0 3	4½	5·7	0·18
7-in. water-bound macadam	120,000	1	120,000	3 0	1	9	5½	6·8	0·15	9 0	0 5	2 3	11	2·1	0·47
Do. tar-sprayed	120,000	2	240,000	3 2	1	6	2½	9·7	0·10	9 4	0 5	1 6	4½	3·0	0·34
Foundation.															
9-in. concrete	524,000	60	26,200,000	4 3	2	—	—	149·0	0·007	13 0	0 9½	—	—	30·5	0·03
6-in. concrete	150,000	50	7,500,000	3 0	1½	—	—	56·8	0·018	9 6	0 7½	—	—	11·8	0·08
	204,000		10,200,000					77·3	0·013					16·0	0·06
10-in. rock pitching	120,000	50	6,000,000	1 3	½	—	—	90·9	0·011	4 6	0 3½	—	—	19·5	0·05

Road Surfaces.—The application of power on our public roads at useful speeds was only made legal in 1896.

Developments, comparatively slow at first, but much more rapid in recent years, have taken place so that to-day millions of tons of heavy and light motor traffic alone are making use of some of our roads. Great changes have taken place in road surfaces due to the introduction of this motor traffic, both light and heavy, with the general increase of speeds involved therein. Undoubtely still greater advances in economical transport by road are bound to come.

The perfect road surface, even for present conditions has not yet been determined, and the stage of experiment and experience must continue even if we have to provide only for the stresses brought on the surfaces by the present varied methods of applying motor power, character of wheels, and their tyres and speeds. The ordinary macadam road surface, which fairly met the requirements of horse traffic, is gradually giving way throughout the country, and being replaced by surfaces more suited to the new conditions, whilst in towns the conditions of traffic have for a considerable time necessitated the provision of paved surfaces on concrete foundations of a strength sufficient to withstand the action of very heavy loads.

Experience to date with pavements show that for traffic involving really heavy loads on steel-tyred wheels, the best quality stone-set pavement is still the most economical. If hard stone can be machine-dressed as accurately as soft wood blocks and more cheaply than the ordinary dressing by hand labour, as now seems possible, the stone-set pavement may well continue to be the cheapest as well as the best surface to meet the new conditions wherever really heavy traffic has to be provided for.

The accurate cutting of soft wood blocks to size by special machines, combined with the more accurate finish of the concrete foundation, has made it possible to obtain very finely finished road surfaces in this material, and the best work of this class has given results which probably cannot be excelled by any other surfacing material in shopping streets of moderate width carrying a large amount of lighter type traffic, and its life appears likely to be much increased by the change from steel to rubber-tyred wheels and the reduction in the amount of horse traffic.

With regard to surfaces for roads throughout the country, cases will, no doubt, arise where the amount of heavy traffic is so great that paved surfaces will have to be adopted, as has indeed already been the case in parts of Lancashire between important towns. The lighter surfaces provided by the different types of asphalt, tar macadam, and pitch macadam, appear to be more generally favoured for ordinary traffic in this country.

A few lengths of road have been laid in England of the American type of concrete road surface, in which the wear is being taken by the concrete direct. The feeling amongst English engineers appears to be in favour of surfacing concrete roads with a slight coat of tar, pitch, or asphalt mixture, in the nature of a carpet, and I find that in Liverpool a pavement of this type is at the present time the cheapest type of construction which can be put down for the residential and light traffic streets, and a large area of this class of work is at the present time in hand.

Loads which quickly destroy macadam do little damage to well-paved surfaces, and it is very doubtful whether a sound and economical policy has been adopted in fixing as a maximum for town streets the loads allowable on motor-wagons throughout the country generally without making provision for a relaxation similar to that provided under the Highways and Locomotives (Amendment) Act, 1878. Net loads of 12 tons behind two horses along the line of docks in Liverpool are quite common whilst if the law is strictly followed the same weight on a 50 h.p. motor-wagon cannot be permitted.

Special powers as to increased loads should be applicable to meet the requirements of special traffics in such cases and on thoroughly good town pavements there appears to be no good reason why net loads of 20 tons should not be allowed on rubber tyres, as it is well known that such loads are commonly carried on four wheels with steel tyres behind traction engines along roads adjoining docks and large engineering works.

The great value of thorough and systematic experiment, and the testing of different surface materials, is well shown in the case of a heavy traffic street in Liverpool, where, in 1872, one of the earliest types of cement concrete foundations, supporting imperviously-jointed paving, was introduced by the late G. F. Deacon, then Borough Engineer of Liverpool. For the surface materials, he selected a large number of different types of stones, had them dressed to accurate sizes and most carefully paved in separate areas coming under similar traffic conditions. It is a remarkable tribute to the thoroughness of his methods that, though many of the softer materials have been worn away and replaced, one complete length of his paving still exists, and is to-day in a reasonably satisfactory condition, having required in the meantime remarkably little repair, though carrying for nearly fifty years some of the heaviest classes of traffic in Liverpool, probably averaging nearly 200,000 tons per yard of width per annum, or a total traffic life to date of over 9,000,000 tons per yard of width. At the end of fifty years it is hoped that the sets can be turned, and the whole area repaved at little or no expense for new materials, and the length of street restarted on a fresh lease of life, which, under the new conditions of rubber-tyred traffic, is likely to be even more lengthy.

The great necessity for the accurate information obtainable from actual tests under different conditions of traffic induced the Road Board to arrange for some valuable experiments in the County of Kent, under the present Director of Roads in the Ministry of Transport, and the important results obtained were made available for all road engineers. Similar experiments with local and other materials in every county in the kingdom would have been money well spent, as all classes of work and materials could in this way have been fully tested under the different local conditions of climate and traffic, and care should have been taken to obtain accurate first costs, accurate maintenance costs, accurate measurements of wear, and the other items of information which although involving trouble and expense, are necessary if careful and reliable comparisons are to be made on the lines which are customary with engineering tests generally.

Such experiments would have afforded valuable education, as they would also have enabled all road engineers to compare the efficiency of the different methods of handling the work by various contractors, and of seeing and, where necessary, of acquiring the most up-to-date machines for dealing with the various classes of materials about to be tested. Unfortunately accurate information in regard to wear or life and costs of road surfaces under given conditions of traffic, has not in the past been generally available, and without such information it is often difficult to decide what class of wearing surface will be the most economical in any particular case.

A table is given on the preceding page showing cost and life of various pavements. Costs are given both on a pre-war and present-day basis. The latter figures are not so reliable as the former, due to the variations in cost of labour and materials, which are now so much greater than formerly, and will, therefore, require modification from time to time. It is also likely that the lives will have to be extended due to the change from iron-shod horses and vehicles to the now more generally used rubber tyres.

Reorganisation of the Road System.—It appears to me that a very thorough reconstruction and reorganisation of the road system is one of the most urgent problems of our time. In a great many cases railways and canals must continue to afford the best means of transport for heavy loads over considerable distances. It is also probable that in the future the aeroplane or airship will be freely used for mails, and a certain amount of light and valuable merchandise, but I cannot doubt that, owing to the development of road vehicles of which I have spoken, such vehicles will be used to an immensely greater extent than has been the case up to the present time in transport between the actual factory and ship.

The lengths of roads requiring earliest attention are probably those which are in or near the outskirts of the larger towns, where the provision of new houses on a large scale is at the present time being carried out, or where, in the ordinary course of development, lengths of improved road will be necessary, and can still be arranged for and carried out at a comparatively small expenditure before building takes place. Special attention should also be given to the neighbourhood of the smaller towns through which main roads pass, where serious obstruction takes place, and where there is still the possibility of obtaining land for the construction of by-pass roads, and thus avoiding heavy expenditure on the acquisition and demolition of buildings.

Modifications on a large scale usually require time for their completion, and involve large expenditure of public money, but it may be that in the near future work will have to be provided for large numbers of the younger and more able demobilised men who, owing to war conditions, have missed the opportunity of receiving a training in any of the usual branches of work, which have been, during the war, practically at a standstill.

Numbers of such men have been absorbed in the various works in connection with the provision of additional and improved housing accommodation so badly needed in many places, but it is difficult to see any class of work on which, under present conditions, men without training can be employed, which is likely to be of more permanent value to the country at large than the provision of improved roads such as I have referred to, and which, in any case, would have to be carried out in the near future.

I have endeavoured in this Address to deal in a general way with some of the engineering features connected with improvements in the older areas of towns, and the provision of roads for passenger and general traffic, upon which the satisfactory development of the new areas in large towns will very largely depend, not only because it is work of a character which circumstances have made it necessary that I should study and develop, but because problems connected with it are likely to be some of the most pressing of the immediate future requiring solution at the hands of engineers.

None of my contemporaries can have failed to be impressed by the progress made during the period of their engineering experience, and to glory in and be uplifted by that progress so far as it has affected the sciences and arts of Peace. And although it is true that the rapid advance of knowledge has at the same time made immeasurably greater than formerly the horrors of war, as exemplified by the terrible catastrophe from whose ruins we are not yet fully emerged, it is our privilege to hope that such relapses into scientific barbarism may not recur, and that Peace may fully resume and maintain her beneficent sway.

Gentlemen, I am an optimist in such matters, and it is in the full trust that civilisation is bound again to advance and recover the ground temporarily lost, that I have called attention to the matters most prominently mentioned. There are some who say that when the world in general shall have come back to something like pre-war conditions, Britain cannot hope to occupy her old favourable position amongst competing nations. One of the reasons for adopting a pessimistic view is the idea that the relation of capital and labour in these islands will be such as to rule her out of the competition. I think this view places too low a value on the general sense of the British people. Personally, I cannot doubt that any differences that appear—and such differences are perhaps inevitable—shall be settled according to the dictates of common-sense to meet the conditions arising, so that Britain shall retain her position in the forefront of the world's civilisation, her natural resources more fully developed, her industries improved and extended, her commerce grown wider and ever wider.

THE CONSTITUTION OF THE NICKEL-IRON ALLOYS.*

By D. Hanson, M.Sc., and Hilda E. Hanson (National Physical Laboratory).

I.—Introduction.

This paper describes an investigation into the constitution of the nickel-iron alloys, in which special attention has been given to :—

1. The determination of the effect of small quantities of nickel on the critical points of pure iron.

2. An examination of Osmond's theory of the nickel-iron alloys and the determination, if possible, of the "stable" diagram of the nickel-iron alloys.

A considerable amount of work has been done on the alloys of iron and nickel, particularly on nickel steels, by Hopkinson, Osmond, Hadfield, Arnold, Dumas, Guillet, Fraenkel and Tammann, Guertler, Benedicks, and others, and the results of these researches have been embodied in a constitutional diagram. This diagram is largely the result of observations on magnetic properties and electrical resistances of the alloys, but Osmond has obtained some thermal curves over a small portion of the system at the iron end of the series in which the arrest points correspond very closely to the temperatures at which the magnetic and electrical changes occur. Osmond found that with increasing percentage of nickel the points on the thermal curves became less pronounced, and he did not obtain any curves showing arrest points with alloys containing more than 25 per cent. nickel.

Table I.

Alloy.	Percentage Nickel.	Percentage Carbon.
FN1	1·09	0·046
FN1·5	1·52	—
FN2	1·93	—
FN3	3·30	—
FN4	4·15	—
FN6 (silicon, 0·030 per cent.)	5·69	—
FN8	7·95	—
FN9	9·8	0·026
FN11	11·4	trace
FN13	13·00	—
FN15 (sulphur, 0·097 per cent.)	15·14	—
FN20 (phosphorus, 0·076 per cent.)	20·16	—
FN25	25·50	0·032
FN30	29·39	—
FN35 (silicon, trace)	36·20	—
FN40	40·98	0·032
FN50	49·12	—
FN60	58·71	0·025
FN70	69·53	—
FN80	79·29	0·022
FN90	90·71	—

A great deal of the previous work on the constitution of iron-nickel alloys has been in connection with the ternary system of nickel steels, and even where the ferro-nickels have formed the basis of research the percentage of carbon has not been below about 0·2 per cent. Guillet and Osmond afterwards assume that 1 per cent. carbon is equivalent to 17·5 per cent. nickel and 1 per cent. manganese to 2 per cent. nickel, and this assumption is made use of in the construction of a constitutional diagram for the system iron-nickel.

In the present research special precautions have been taken to prepare alloys free from carbon, with the result that the highest percentage of carbon determined by analysis was 0·046, and in the other samples tested the percentage was lower still. With these alloys thermal curves have been taken right across the series, and it is only in the case of those alloys containing 30 per cent. to 40 per cent. nickel that no arrest points have been obtained. From other evidence it appears that the temperature at which the change would take place is so low that the reaction is too slow to be registered on an ordinary thermal curve.

The results of the thermal curves have been confirmed and amplified by electrical resistance measurements on certain of the alloys during slow cooling and slow heating, and also by a series of quenchings from different temperatures followed by microscopic examination.

II.—Preparation of Alloys.

The alloys were made up from Armco iron and Mond nickel shot.

Analysis of Armco Iron used.

	Per cent.
Carbon	0·012
Silicon	0·017
Sulphur	0·017
Phosphorus	0·014
Manganese	0·07
Iron	99·87 (by difference)

The iron and nickel were melted together to form 50-gramme ingots in small alumina crucibles. These were heated in a "carbon ring" furnace,† provided with a china clay liner,‡ through which purified nitrogen was

* Paper read before the Iron and Steel Institute, at Cardiff, September 21, 1920.

† W. Rosenhain and E. A. Coad Pryor, *Transactions of Faraday Society*, 1918.

‡ The authors are indebted to Mr. E. A. Coad Pryor, B.A., for supplying them with specially refractory alumina crucibles and furnace liners.

passed. When these precautions were taken the ingot was practically free from carbon, and the iron-nickel alloys were therefore made up under these conditions. The alloys were all analysed for nickel, in six cases the carbon percentage was determined, and in single cases the percentage of silicon, sulphur, and phosphorus was also determined as a check on the materials used. The results of the analyses are given in Table I.

As a check on the uniformity of the alloys, analyses were at first made from the top and bottom respectively of the ingot; the results were found to be identical, and in subsequent analyses turnings from both top and bottom of each ingot were taken in about equal quantities for each analysis. The microstructure of specimens from three of the alloys in the cast state was examined, the specimens being polished and etched with the cupric reagent. The structure showed coring in each case. Examples are shown in Figs. 1 and 2. The ingots were therefore annealed in batches of six or eight for about six hours at 1,300° C. in the carbon ring furnace, the same precautions being taken as before to prevent carburisation, and the ingots were coated with alundum cement to prevent sticking or diffusion. This preliminary treatment to secure uniformity of composition was given to all the alloys before they were used for any purpose in connection with this research. Examination by etching subsequent to this treatment showed that coring had been removed.

Fig. 1. × 150 Diam. FN25 as Cast. Etched with NPL Cupric Reagent.

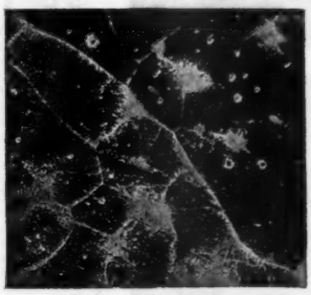


Fig. 2. × 150 Diam. FN70 as Cast. Etched with NPL Cupric Reagent.

(Reduced by One-Tenth.)

III.—Thermal Curves.

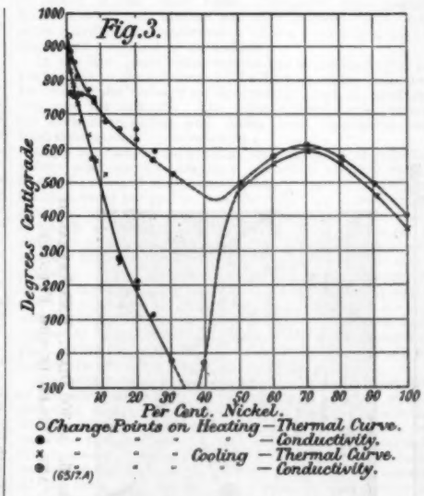
Thermal curves of the alloys were taken *in vacuo*. A platinum-rhodium couple was used, and the end of the couple was placed in a hole drilled into the middle of the cylindrical ingot and wedged in with previously ignited asbestos wool. The ingot and thermocouple were placed in a long silica tube closed with a rubber stopper through which passed the thermocouple wires and a glass tube which was sealed up after the apparatus had been evacuated. The heating was carried out in an upright nichrome-wound silica tube gradient furnace,* in which a temperature varied from about 100° C. at one end to 1,000° C. at the other; the tube containing specimen and couple could be lowered or raised, in this furnace at any desired rate by means of an electric hauling device. The cooling curve was always taken before the heating curve in order to ensure uniform conditions throughout the series.

The curves were obtained with this apparatus in conjunction with the Rosenhain plotting chronograph, and the temperatures at which arrest points occur are given as nearly as possible in Table II. As readings were taken every 50 microvolts with a rhodium couple, the temperature at which the changes took place could only be determined within about 5° C. Fig. 3 shows the diagram obtained from these results, which is very similar in outline to those already published by Hegg, Guertler and Tammann, Ruer and Schuz and others as the result of magnetic determinations, and to that obtained thermally by Osmond for the alloys containing less than 25 per cent. nickel. The actual temperatures are not identical, but as the present diagram is based on results obtained with carbon free alloys this was not to be expected. The arrest points, on the curves for the nickel-rich alloys are smaller than in the case of the other alloys, but they are sufficiently definite to allow the transition temperature to be determined within about 10° C. in each case.

IV.—Electrical Conductivity.

In the thermal curves no arrest point was obtained on the cooling curve for the alloy containing 25 per cent. nickel, nor on either cooling or heating curves of FN30 and FN40. There is also no indication on any of the curves of a structural change between 300° C. and 400° C., such as is suggested by the hypothetical "eutectoid" line in the diagram of Osmond† and by the work of Benedicks.‡

Some experiments have therefore been carried out on the electrical conductivity of the alloys during slow cooling and slow heating, the rate of change of temperature in each case being very much less than when the thermal curves were being taken. The apparatus used was that described by J. L. Haughton, D.Sc.§ The specimen in the case of each alloy was about 1 in. long and 0·1 in. in cross section at the ends, the centre part being hammered so as to make the whole into the shape of a dumb-bell. The nichrome wires connecting the specimen with the apparatus were passed through fine holes at the ends of the specimen, and drawn through a rubber cork fitting a silica tube in which specimen and wires were enclosed. Good contact between the wires and the specimen was ensured by hammering the junctions while hot. In one or two cases, where a thinner specimen than usual was employed, connecting wires of thin copper were passed through small holes and wound tightly round the ends of the specimen, but as the contacts were not so good a less regular curve was obtained. The stopper was also fitted with a glass tube which was sealed off when the tube was evacuated. A platinum-rhodium thermocouple was fastened to the outside of the tube and was connected with a thread recorder. The furnace consisted of a wire-wound silica tube with supplementary windings at each end, which were controlled separately from the main winding, to ensure uniformity of heating. Preliminary tests showed that for at least 3 in. of its length the temperature was constant. The heating current supply was controlled by a high-temperature thermostat* which would allow the furnace to be kept at a constant temperature for any desired length of time, *e.g.*, overnight, and could also be adapted to provide very slow cooling or heating. In this method the potential drop across a fixed portion of the specimen is compared with that across a standard resistance in the same circuit, by connecting each in turn to a sensitive galvanometer, and in order to make comparison more simple, the deflection due to the standard is brought to a fixed constant value immediately before each reading of the deflection due to the specimen, a variable resistance being included for this purpose. Readings were taken at intervals varying from 5° C. to 20° C.



In spite of the uniformity of the furnace, there was nearly always a slight thermal electromotive force due to differences in temperature from end to end of the specimen, and correction was made for this after each reading. The actual resistances for each alloy were not calculated, but the deflections at successive temperatures are plotted to give the curves shown in Fig. 4. In Table III. are given the temperatures at which changes in the direction of the curves took place, and the time occupied in taking each curve. The "change-temperatures" are plotted against the percentage of nickel in the diagram in Fig. 3, where they may be compared with similar determinations obtained by means of thermal curves. It is interesting to note that by this method transformation points have been detected in the case of some alloys where the methods of thermal curves had failed.

There is a sharp change in the direction of the cooling curve for each alloy at the transition point, but the change is more gradual on heating. The change point on heating is therefore taken as the temperature at which the curve joins or becomes parallel to the cooling curve. In FN40 and FN50 the curves are uniform throughout and have no definite point at which a change of direction takes place. Besides these well-marked changes at the temperatures which are given in Table III., in several of the curves there is an indication of another change at a higher temperature. This is particularly evident on the cooling curves of FN8, FN20, FN25, and FN30 respectively; the meaning of this is obscure, and no structural change could be found associated with it. The conductivity curves for FN1 show only one change in direction, and give no clear sign of the point A3 above 800° C. on the corresponding thermal curves.

Table II.

Alloy.	Arrest points.	
	Cooling Curve.	Heating Curve.
	Deg. C.	Deg. C.
FN1	825	886
	760	760
FN1·5..	735	858
	750	766
FN2	786	855
		763
FN3	730	815
		758
FN4	680	800
		755
FN6	636	758
FN8	563	730
FN11	526	680
FN15	272	655
FN20	195	625
FN25	—	547
FN30	No arrest points found	—
FN35	No curves taken	—
FN40	No arrest points found	—
FN50	486	500
FN60	550	572
FN70	590	610
FN80	560	572
FN90	457	487
Pure nickel	348	393

Table III.

Alloy.	Change Point.		Range of Temperature.	Time Occupied.	
	Cooling.	Heating.		Cooling.	Heating.
	Deg.	Deg.	Deg.	Hours.	Hours.
FN1 ..	775	775	960–720 370–900	5	8
FN8 ..	562	740	825–15	48	48
FN15 ..	276	?	730–15	34	—
FN20 ..	212	670	730–15	72	72
FN25 ..	108	610	700–10	31	9
FN30 ..	−25 about	520	600–80	48	7½
FN40 ..	—	—	550–80	20	7
FN50 ..	—	—	550–10	0	0

It is of interest to note that the critical points obtained by means of electrical conductivity measurements agree very closely with those obtained by means of thermal curves and, in investigations by other workers, by magnetic tests, in spite of the fact that the rates of heating and cooling used are extremely slow, and much slower than any which have previously been used. In some cases the period of heating or cooling has extended over two or three days. It was hoped that confirmation would be obtained, under these conditions, of the existence of a eutectoid line at about 350° C., as suggested by Osmond, for which microscopic evidence has been offered by Benedicks in an alloy containing 11·7 per cent. nickel; it is somewhat disappointing to find that this method, which is extremely lengthy in operation, does not give any confirmation of the correctness of Osmond's theory of the nickel-iron alloys. The matter will be referred to again later.

V.—Heat Treatment and Microstructure.

The etching of the iron-nickel alloys presented some difficulty, and uniform results were not always obtained after apparently uniform treatment. The alloys rich in nickel required long immersion in the etching liquid, or else the use of strong acid, to bring up the crystal boundaries, and both practices led to tarnishing of the surface; there was also a strong tendency for the etching liquid to eat out holes in the surface of the specimen. The materials used for etching were:—

1 per cent. HNO_3 in alcohol.
15 " " "
50 " " " acetic acid.
4 " picric acid in acetic acid.
N.P.L. cupric reagent.*
Bromine water.

Of these the 1 per cent. HNO_3 in alcohol was found best for iron-rich alloys, *i.e.*, those containing from 1 per cent. to 8 per cent. nickel, 4 per cent. picric acid, and 15 per cent. HNO_3 in alcohol were good for alloys containing 8 per cent. to 25 per cent. nickel and 15 per cent. HNO_3 for the nickel-rich alloys. It was difficult to obtain a good

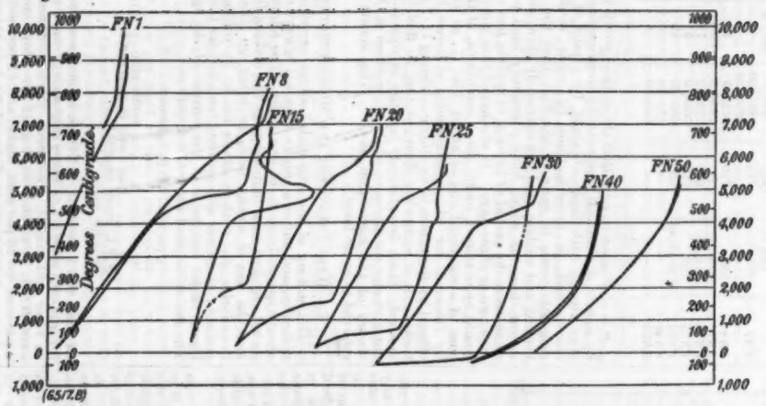
* W. Rosenhain, *Journal of the Institute of Metals*, No. 1, 1915.
† *Revue de Métallurgie*, 1905.
‡ *Ibid.*, 1911.
§ *Transactions of the Faraday Society*, 1920.

* *Journal of the Institute of Metals*, No. 2, 1915, vol. xiv., and No. 2, 1917, vol. xviii.

* *Journal of the Iron and Steel Institute*, 1914, No. I. p. 515.

THE CONSTITUTION OF NICKEL-IRON ALLOYS.

Fig.4.



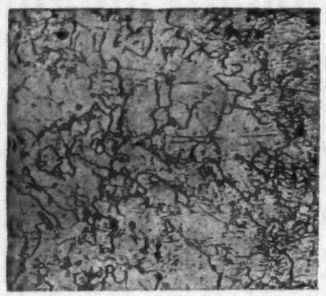


FIG. 5. × 300 DIAM. FN6 ANNEALED AT 1300 DEG. C. AND COOLED IN THE FURNACE.

FIG. 6. × 300 DIAM. FN9 ANNEALED AND COOLED IN THE FURNACE.

(Reduced by One-Tenth.)

FIG. 7. × 300 DIAM. FN13 ANNEALED AND COOLED IN THE FURNACE.

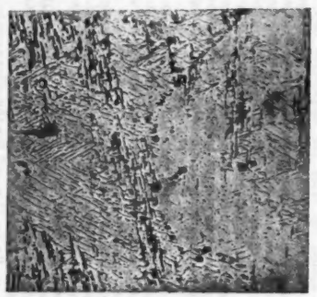


FIG. 8. × 150 DIAM. FN25 ANNEALED AND COOLED IN THE FURNACE.

(Reduced by One-Tenth.)

FIG. 9. × 300 DIAM. QUENCHED STEEL—CARBON 0·5 PER CENT.

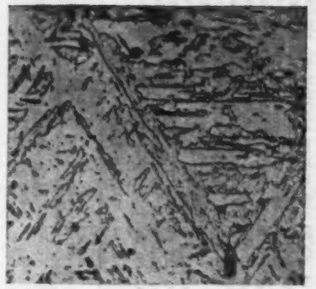


FIG. 10. × 300 DIAM. FN20 ANNEALED AND COOLED IN THE FURNACE.

(Reduced by One-Tenth.)

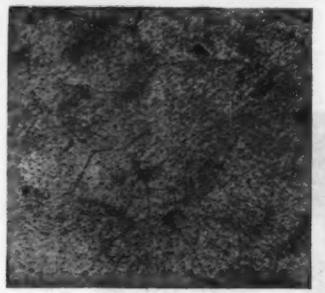


FIG. 11. × 300 DIAM. FN15 HEAT-TINTED ABOVE CRITICAL POINT.

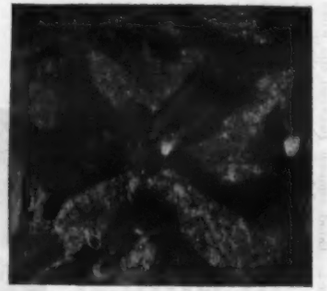


FIG. 12. × 300 DIAM. FN15 HEAT-TINTED BELOW CRITICAL POINT.

(Reduced by One-Tenth.)

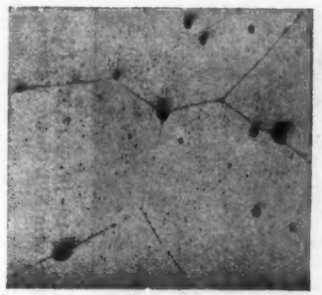
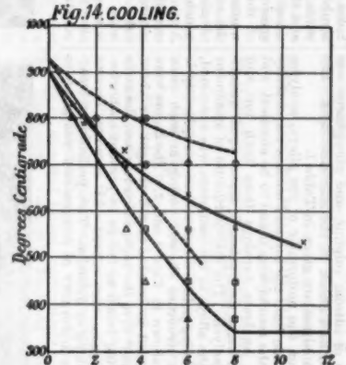


FIG. 13. × 150 DIAM. FN35 ANNEALED AND COOLED IN THE FURNACE.

(Reduced by One-Tenth.)

Fig.14. COOLING.



The Dotted Lines Indicate the Transformation Range on Heating.

○ *Quenched Alloy consists of Martensite.*
□ " " " " *Martensite and Ferrite.*
△ " " " " *Ferrite.*
× *Arrest Points on Cooling Curves.*

(65/7.8)

surface on the latter, and though several reagents were tried, no very satisfactory results were obtained. Bromine, which has been used for the etching of meteorites, gave variable results, sometimes very good, but more often the surface was much pitted. The photographs published are all of structures which were obtained repeatedly after successive polishing and etching treatment.

Microstructure.—The microstructure of many of the alloys has been examined after annealing at 1,300° C. and cooling in the furnace. Under these circumstances the first effect of the addition of nickel is to render the iron more difficult to etch. The crystals, even after repeated polishing and etching, did not possess the clear surface found in pure ferrite, but appeared roughened with an indefinite relief pattern; Fig. 5 illustrates this in the case of alloy FN6 (6 per cent. nickel), and may be compared with Fig. 19,* which represents a true ferritic structure obtained (in a 3 per cent. nickel alloy) by special treatment which will subsequently be described. The crystal size, which is small with low percentage of nickel, increases with the nickel content, and the markings become less indistinct, though there is not much variation in microstructure between 10 per cent. and 25 per cent. nickel. Figs. 6, 7 and 8 may be taken as representative of the alloys over this range. In appearance this structure is very similar to the martensite and austenite-martensite of carbon steels; Fig. 8, for example, may be compared with Fig. 9, which represents a 0·5 per cent. carbon steel quenched from a high temperature. The structures are almost identical. The same type of structure is shown under a higher magnification in Fig. 10, which represents a 20 per cent. nickel-iron alloy. In this photograph the dark martensite is seen in a ground-mass of untransformed austenite. These structures have been observed before by other workers, and have usually been described as austenitic. The authors think that this structure should be clearly distinguished from the austenitic structure in nickel-iron alloys, which is found in certain of these alloys of higher nickel content. The martensitic structure is produced during the passage of the alloy through its transformation point on cooling, and does not exist at higher temperatures, and its formation cannot be prevented by the severest quenching treatment; it is also produced by any ordinary slow cooling operation, and is only broken up when special precautions are taken to obtain specially slow rates of cooling over certain ranges of temperature, or by prolonged annealing at a suitable temperature. The impossibility of preserving the truly austenitic structure of these alloys by quenching is a source of difficulty in studying these alloys (as in the case of steels), since it is impossible to preserve the structure which exists at the quenching temperatures.

That the martensitic structure is produced on cooling through the critical point is proved by the following experiment. A polished, unetched sample of alloy FN15 was heated to a high temperature in an evacuated tube and cooled to 400° C., a temperature higher than its transformation point. A little air was then admitted to the furnace, sufficient in quantity to "heat-tint" the surface of the specimen. The tube was then evacuated, while still at that temperature, and cooled. On examination an etched pattern was found on the specimen, a photograph of which is shown in Fig. 11, in which the boundaries of the austenite crystals are visible, but from which martensitic markings are absent. The structure of the same specimen, heat tinted after passing through the critical point, is shown in Fig. 12. The martensitic markings are here clearly defined.

Alloys containing 30 per cent. and higher percentages of nickel possess a structure consisting of large crystals, from which martensitic markings are absent. In the case of alloys FN30 and FN40, immersion in CO_2 snow (— 80° C.) resulted in the production of martensite. The change points in these alloys are therefore between 0° C. and — 80° C. This treatment was without effect on FN35. Fig. 13 shows the microstructure of sample FN35. With high percentages of nickel the crystals which existed at a high temperature break up into smaller crystals at the transformation line. Fig. 2 illustrates this; it shows portions of two large crystals, separated by a boundary running across the photograph, which have transformed into smaller crystals.

With rates of cooling in ordinary use, the alloys containing from 6 per cent. to 30 per cent. nickel all give either a definite martensitic structure at ordinary temperatures, or one which is so finely divided that it is not resolved under high powers of the microscope. With a nickel percentage in excess of about 10 per cent. it is probable that the alloy in the "furnace-cooled" condition may be regarded as truly martensitic; when the nickel content is less than this, it is probable that separation of α-iron definitely takes place, but on a scale so small that the crystals are not separately visible under the microscope. Experiments have therefore been undertaken, using specially slow rates of cooling and prolonged periods of annealing, with the object of determining, if possible, the manner in which the martensite of these alloys decomposes, and the extent of the "critical ranges" through which this decompositon takes place. In all these experiments, in view of the long periods of exposure of the alloys to high temperatures, the specimens were enclosed in evacuated silica tubes to protect them from oxidation. The tubes containing the alloys were all heated to a temperature of about 900° C. (above the critical range of all the alloys), in which case they exist as homogeneous austenite, which, if the nickel content is less than 30 per cent., becomes martensite on quenching. The temperature of the furnace was then reduced very slowly, and at intervals during this cooling certain of the specimens were removed and quenched as rapidly as possible. They were then polished, etched, and examined under the microscope. The results of these experiments are represented in Fig. 14, which shows the upper and lower boundaries of the critical range on cooling, as determined partly by thermal curves and partly by the microscopic examination of quenched specimens.

(To be continued.)

* Fig. 19 will appear in a later issue.

BENZOLE-ALCOHOL EXPERIMENTS ON OMNIBUSES.

*Fuel Experiments Carried out by the London General Omnibus Company, Ltd., with Benzole-Alcohol on Omnibuses.**

By G. J. Shave, M.I.Mech.E., M.I.A.E.

Actuated by the necessity of finding a suitable substitute for petrol, and at the request of Mr. Long's Inter-Departmental Committee on Power Alcohol, due to the fact that the adequacy of the world's supply of oil to meet the ever-increasing demands is seriously questioned, the company decided to carry out a series of experiments with benzole-alcohol with a view to ascertaining the most suitable mixture of these fuels for operating standard 'buses with "B" type engines.

The Fuels.—Perhaps a foreword with regard to the general characteristics of benzole and alcohol as fuels for use with internal combustion engines may not be out of place before describing the experiments that have been made. Benzole is a product obtained by chemical treatment and distillation from coal tar. The production is limited by the amount of coal which is subjected to distillation—either for the production of coal gas or metallurgical coke—the benzole being one of the minor by-products.

Alcohol is produced from vegetable products, and the raw material is practically limitless, so that no fear exists as with coal and oil of exhausting the supply. For this reason we felt it desirable to find a mixture of these two fuels that would allow as large a proportion of alcohol as could be reasonably used, having, of course, due regard to the economy of fuel and the least amount of alteration necessary to convert a standard petrol engine to burn this fuel. In discussing the merits of these fuels, we must take petrol as our standard for comparison, owing to the fact that the 'bus engine is designed and tuned-up for use with petrol.

Although petrol has the greatest number of British thermal units per pound, benzole has the greatest number of British thermal units per gallon. Alcohol by itself has approximately just over half the calorific value of either of the other fuels. Compared with petrol, both benzole and alcohol are slow-burning fuels, and consequently the construction of the engine has to be somewhat modified to suit them.

In the first place, compression has to be increased in proportion to the slowness of the burning of the mixture, and within the limits of the detonating temperature of the fuel and air mixture. The most suitable compression for certain mixtures and under fixed conditions has been determined by experiment.

Copy is attached (appendix) showing table of calorific values and specific gravities. Looking at this table, it will be noticed that benzole stands highest in British thermal units per gallon, but the difference is very small between that and petrol. It follows from this that, although to obtain the best results from benzole a different carburettor setting is required, it is possible to run the engine with benzole without altering the compression. With regard to alcohol, however, owing to its slow combustion, it was found that good results could only be obtained by raising the compression to a very considerable degree. Another point in connection with the use of these fuels is the temperature of the induction pipe. The temperature should be maintained so as to ensure the complete vaporisation of the fuel.

Mixtures.—With regard to the question of the mixtures of benzole and alcohol, it is possible to make a whole range of fuels which have various calorific values in British thermal units per gallon. Pure benzole can be used as a fuel, and also pure alcohol and every proportion of mixtures of these two fuels. Within this range of fuels comes the value of the present-day petrol, approximately 92 per cent. benzole and 8 per cent. alcohol; so it is quite possible to make a mixture which can be used on the petrol engine and to compare favourably with petrol without making any change of compression or carburettor setting. This is not necessarily the best setting or conditions for using this mixture, nor is it necessarily the mixture of alcohol and benzole that can be obtained to produce the best all-round results.

Bench Tests.—We determined first to commence with the 50 per cent. mixture. Here we have a fuel the heat value of which, as compared with petrol, is as 12·5 is to 15, a difference which warrants considerable change in the compression of the engine and the setting of the carburettor.

Some 50 bench tests were made on a 110-mm. by 140 mm. "B" type engine by means of a dynamometer. The compression, the setting of the carburettor, and the heating of the induction pipe were the variable factors experimented on. As a result of this work, we found that with the 50 per cent. mixture the 123-lb. compression gave the best results. The valve setting found most suitable was the same as that in standard "B" type engines using petrol. The exhaust gases were analysed on this test (123 lb. compression) and showed a complete absence of carbon monoxide, with a slight excess of oxygen, showing that the combustion of the fuel was complete. Following this, further bench tests were made to investigate the possibility of running "B" type engines standard in general details, but with higher compression on fuel mixtures with higher percentages of alcohol.

During these tests, the large range of mixtures of air and fuel with which the engine could be run was particularly noticed. This was more noticeable when the alcohol was present in large proportion in the fuel, and proved conclusively the serviceability of fuels containing alcohol. In these bench tests, it may be a point of interest to mention that the full load fuel consumption of British thermal units per brake horse-power decreased as the percentage of alcohol became greater, up to the point where the compression was not sufficiently high (*i.e.*, mixtures containing up to 70 per cent. or 80 per cent. alcohol).

The half-load consumption gradually becomes greater, and the quarter-load rapidly becomes greater. This points to the effect due to the low compression obtained with small throttle openings, and it is suggested that the advantages gained at full throttle when using higher percentages of alcohol will be reduced by reason of the lowered economy at light throttle openings, especially on the type of engine on which these trials were made. With reference to the shape of the combustion head, it is contended that the higher the compression is made with this engine the relatively worse effect will the pockets have on the fuel consumption, more especially at the small throttle openings. This observation leads one to the conclusion that the greater the percentage of alcohol the more important it is to design the engine for that special purpose. A slow-burning fuel, such as alcohol, makes it possible to reach high thermal efficiency and great fuel economy, but in order to obtain the best results, it is necessary to design the engine to suit the fuel. Generally speaking, such an engine would have a long stroke and high compression with overhead valves. The importance of introducing sufficient heat thoroughly to vaporise the mixture cannot be over-emphasised.

Briefly to summarise the result of this range of tests, we may say:—

(*a*) The greater the percentage of alcohol, the higher are the possible thermal efficiencies for the same compression.

(*b*) The greater the percentage of alcohol, the higher can the compression be raised with the consequent rise in the thermal efficiencies.

(*c*) With high compression the ill-effects of valve pockets are more noticeable at small throttle openings than with low compression.

Road Tests.—In view of the promising results obtained on the bench with high compression, it was decided to put the engine tested into a 'bus chassis and conduct some road trials, the results of which are as follows:—

The chassis with which these tests were made was a 'bus chassis fitted up as a lorry. The engine compression had been raised to 160 lb. per square inch by riveting aluminium plates to the top of the pistons. These plates were dome-shaped so as to follow, more or less, the contour of the cylinder head. In order to ascertain the mixture most suitable for use with this compression the following mixtures were tried:—

Alcohol. Per Cent.	Benzole. Per Cent.	Calorific Value per B.T.U. per Gallon.
90	10	100,000
80	20	109,487
70	30	115,347
60	40	120,207
50	50	127,063
Petrol	—	151,305

These tests were made on our standard test run, 8 miles out and 8 miles return, and the roads on the whole were in a very fair condition, and generally in a dry state. The route is on the Epping road, through Woodford and Epping. It is an undulating road, the gradients being generally rising in the outward direction, so that the return route is rather the more favourable of the two.

It was observed that the best all-round results were obtained with the 70 per cent. to 30 per cent. mixture, although the 50 per cent. mixture gave quite good results. Comparing the 70 per cent. mixture (high compression) and petrol (normal compression) we get:—

	70 Per Cent. Mixture.	Petrol.
On a bench rest—		
B.T.U. per mile ...	12,160	16,100 (normal speeds).
Saving of B.T.U....	— 24·5 p.c.	—
On road-service test—		
B.T.U. per mile ...	14,100	15,810
Saving of B.T.U....	— 10·8 p.c.	—

Tests on Service.—After the road test the same engine was transferred to a 'bus, the latter having been fitted with new fuel tank, pipes and fittings. It was then put on service running on the 50 per cent. benzole-alcohol fuel. After running on service for a month the new tank was found to have become porous and corroded, evidently from the action of the fuel. To further investigate the corrosive effect of this fuel, the laboratory undertook a series of experiments in the action of benzole, alcohol and 50 per cent. mixture on different metals, and from their report it appeared that copper and iron are attacked very badly by these fuels; brass, zinc, aluminium and tin are slightly attacked; and no action takes place on lead. It is important, therefore, that the fuel tanks and pipes should be lead coated. The tanks could be made of sheet iron coated with lead, and the pipes should be of steel with an internal coating of lead. A sample of sheet iron suitable for this purpose has been received. This metal is coated with an alloy 20 per cent. tin and 80 per cent. lead.

With regard to the carburettor, this can still be made

* Paper read at the Conference called by the Imperial Motor Transport Council in London, October 19, 1920.

of brass, as the fuel affects the brass only very slightly. The results obtained on service are as follows :—

—	Total Miles to Date.	Fuel Consumption. 'Bus Average to Date on Mixture.	Fuel Consumption. Fleet Average to Date on Petrol.
Week ending July 16, 1919.			
75 per cent. benzole, 25 per cent. alcohol—			
'Bus No. B 908	4,597·7	—	—
Miles per gallon	—	7·42	7·58
British thermal units per mile	—	18,980	19,900
95 per cent. benzole, 5 per cent. alcohol—			
'Bus No. B 415	2,632·4	—	—
Miles per gallon	—	7·6	7·58
British thermal units per mile	—	20,150	19,900
Week ending September 10, 1919.)			
80 per cent. benzole, 20 per cent. alcohol—			
'Bus No. B 849	6,746·4	—	—
Miles per gallon	—	7·28	7·55
British thermal units per mile	—	19,780	20,050
50 per cent. benzole, 50 per cent. alcohol—			
'Bus No. B 1,263	4,567·6	—	
Miles per gallon	—	7·0	7·55
British thermal units per mile	—	17,816	20,050

From this it will be seen that the 50 per cent. benzole-alcohol mixture gives the most efficient result, consuming some 12½ per cent. less British thermal units per mile than petrol. The next best result is with 75 per cent. benzole and 25 per cent. alcohol.

Referring again to the 50 per cent. mixture, the experimental engine which had been running in a "B" type 'bus was taken out for examination after running about six weeks on service. Before opening up this engine a test was made on the stand to find out whether it was doing as well as it did when it was first sent out. The results obtained show that the fuel consumption had somewhat increased and the brake horse-power had decreased as compared with the first test of this engine before being put into the 'bus. On opening up the engine one cylinder was found to be badly scored by a gudgeon pin. The inlet valve pockets and so far as 1 in. under the valve heads were coated with a thick tar-like substance, choking to a large extent the passage. The exhaust valves were quite clean and in good condition. There was not much deposit on the pistons. There was a little of this tar-like deposit in the induction manifold. The partial choking up of the inlet valve openings would probably account for the decrease in horse-power observed on the second bench test.

It would seem advisable, therefore, periodically to examine the valves and induction pipe, say every month, when running on this fuel. On the other hand, no ill-effects from the point of view of running on service were noticeable during the latter part of its run; in fact, the miles per gallon seemed to have been fairly well maintained throughout the whole period. The ease of starting, the acceleration and flexibility, and the pulling at low speeds were very noticeable. There was no knocking or pinking in the engine when negotiating hills at low speeds. This is due to the combustion of fuel in the cylinder being more sustained, and the absence of the tendency to pre-ignition or to detonation.

A further 14 'buses were then worked on service, and in the main were run on the 50 per cent. mixture of benzole-alcohol. During the period they were running the average fuel consumption was 7 miles per gallon during the six weeks' operation of over 4,500 miles. At the same time the average on petrol (for the same period) was 7·5 miles per gallon. With regard to the experience obtained during this time, several features were observed which affected the economy of the fuel in various ways—colder weather, indifferent supplies of benzole, and the separation of water out of the alcohol. This, combined with the bad state of the roads, all contributed to lower the economy compared with the figures originally obtained. The benzole trouble was eliminated by getting fresh supplies up to standard specification. The excess of water in the alcohol may have been due to colder weather and more humid atmosphere; at any rate, it had the effect at the time of making the 'bus difficult to start and also of causing trouble on services where mica plugs were used, owing to the condensation of water on the plugs. This trouble was overcome by using plugs with porcelain insulation to within a short distance of the point of the electrode. To eliminate the difficulty of the excess of water in the alcohol at starting a drain tap was fitted to drain off the water before starting-up in the mornings. It is suggested as an explanation of the collection of water in the tank that alcohol, benzole and water are not completely miscible at low temperature.

In mentioning these troubles it should not be deduced that the experiments were unsuccessful, for, as a matter of fact, after the elimination of these earlier difficulties, the operation of the 'buses on service was entirely satisfactory. There was a noticeable absence of "pinking" or knocking in the engines, the running of which were good, developing and sustaining a high torque at low speeds. These features are attributed to the slow burning of the fuel. In spite of the higher compression the garage staff have had no difficulty, other than the above-mentioned experience, in starting up the engines in the early morning.

An average fuel consumption taken over a period of two winter months with some half-dozen 'buses in service works out as follows :—

Fifty per cent. mixture, 6·05 miles per gallon.
Petrol (fleet average), 7·19 miles per gallon.

During the summer months the comparison was as follows :—

Fifty per cent. mixture, 7 miles per gallon.
Petrol (fleet average), 7·55 miles per gallon.

When considering these figures regard must be paid to the fact that it is difficult to estimate the economy effected by using the 50 per cent. mixture as against petrol, as we purchase our fuel by gallons and not by British thermal units.

Comparative Cost of Fuels.—We cannot justly compare the price paid for petrol, benzole and alcohol owing to the abnormal state of the markets, and in the case of alcohol, the heavy Government duty imposed. However, the report mainly deals with the advantages and disadvantages of running 'buses on 50 per cent. benzole-alcohol mixtures from a technical point of view to assist in determining whether the advantages gained warrant an encouragement of the production of these fuels by the Government and a revision of the taxation. On the basis of equal cost per gallon, say 2*5d.* per gallon, we get the following comparison in British thermal unit per 1*d.* :—

	Petrol.	50 Per Cent. Benzole-Alcohol.
British thermal units per 1*d.*	6,050	5,000
British thermal units per mile	20,050	17,816
Cost per mile	3·3*d.*	3·5*d.*

This shows that petrol has 20 per cent. more heat value per 1*d.* than the 50 per cent. mixture, but the latter is 12 per cent. more economical. The difference in cost is, however, only 8 per cent., the petrol being the cheaper fuel on the assumption of equal cost per gallon. Apart from the question of greater heat economy, the running of the engine is very much better than when using petrol.

The question of using alcohol as a motor fuel has been gone into in the past, but, owing to the illegitimate uses to which it might be put and the high taxation involved, no serious attempt has been made by the Government to relax the legislative restrictions in dealing with this spirit for motor-fuel purposes. Methylated spirit is a commercial alcohol that has been denatured by the admixture of other substances to make it undrinkable. The main addition is 10 per cent. wood naphtha (or methylating alcohol), which latter substance reduces its efficiency as a fuel.

It is suggested that a way out of the difficulty would be for the Government to authorise a motor fuel made of definite proportions of alcohol and benzole, such as 50 per cent. mixtures here reviewed. The alcohol would thus be denatured by the benzole, and the mixture might be sold as a Government fuel, the mention of alcohol being omitted. The taxation on this fuel should not be higher than that on petrol. It may be mentioned that this procedure should not adversely affect the revenue, insomuch as this fuel would be in addition to the alcohol used for other trade purposes, and on which the present duties would be still demanded. We have now discontinued this experiment, and are confining our attention to experiments with mixtures of alcohol and ether, and alcohol, benzole and ether.

Alcohol-Benzole-Ether Mixture Experiments.—This experiment is not yet very far advanced, but we can give some data as regards bench tests made with this mixture.

The fuel was prepared from denatured alcohol, Anglo benzole, and methylated ether. Allowance was made for the benzole in the denatured alcohol (this being determined at 7½ per cent. to 8 per cent.), and the mixture used had the following composition :—

	Per Cent.
Alcohol	65
Benzole	30
Ether	5

The specific gravity of this mixture was 0·8265 at 60 deg. F.

Preliminary tests were carried out for the purpose of getting the best all-round setting. Three types of induction pipe were used—plain, exhaust heated and water-jacketed—the last giving the best results, while the exhaust-heated pipe gave the worst. It was possible to start from cold easily, using either plain or water-jacketed induction pipes, though in the latter case steady running was not obtained until the engine had become hot.

The bench test results are appended, and show that, compared with petrol, the power at speeds below 900 r.p.m. are slightly better, while at high speeds they fall off. The consumption is, however, slightly higher with this mixture than with petrol, this being rather more marked at quarter load. The acceleration was good from 360 r.p.m. in all cases, and there was a complete absence in knocking and pinking. The analysis of an exhaust gas sample gave satisfactory figures, the absence of carbon monoxide indicating that combustion was complete. The plugs and valve caps were removed after the test, and only the slightest deposit was noticed on them. There was no objectionable smell from the exhaust. The calorific value of the mixture, given in the appendix, was calculated. The thermal efficiencies obtained with this mixture are higher than the figures obtained for petrol.

It is to be particularly noticed that the complete test was carried out on a standard "B" type engine of normal compression. Experiments of this kind entail a considerable amount of work, and we trust that the results of our efforts may be of some use in determining what is to be the ultimate substitute for petrol. We are fast squandering the oil that has been stored in the fuel beds of the world, and it seems, so far as our present knowledge takes us, that it is to the fuels experimented with that we must turn for our salvation.

APPENDIX.

Table of Calorific Values and Specific Gravities.

—	B.T.U. per Lb.	Specific Gravity at 60 Deg. F.	B.T.U. per Gall.
Petrol..	19,705	0·768	151,305
Benzole	17,932	0·872	156,367
Alcohol	11,952	0·782	93,465
50 per cent. benzole, 50 per cent. alcohol ..	14,906	0·838	124,916
65 per cent. alcohol, 30 per cent. benzole, 5 per cent. ether ..	13,410	0·8265	110,816

Société des Ingénieurs Civils de France.—The British Section of this society intends to hold a few meetings, probably four, or possibly six, during the session 1920–21. The first of these meetings has been fixed for Tuesday, November 9, and will take place in the Hall of the Royal Society of Arts, John-street, Adelphi, when a paper will be read by Mr. E. Gruner, President of the Society, on "The Destruction of the Mining District of Northern France, and the Work of Reconstruction." A dinner will take place on November 10, in honour of Mr. Gruner. Further information can be obtained from the Secretary, 45, Great Marlborough-street, W. 1.

Death by Direct Current of 220 Volts.—Though direct currents of 500 volts are considered relatively safer than alternating currents of 100 volts, whilst the high frequency currents of electric apparatus are generally harmless, fatal accidents have been produced by direct currents of low potential. Three quite recent cases are reported from a coal mine in Upper Silesia. A man who had been shunting the coal trucks, was found dead, killed apparently by having come in contact with 220 volts trolley wire; the temperature down below was high, 28 deg. C. (82 deg. F.), and the man, who had nothing on but a pair of trousers and shoes, had been perspiring. In another place two men were killed by having been struck by the breaking trolley wire; they were riding on an iron truck. A third man with them was revived.

The "Fullagar."—This electrically-welded coasting vessel built by Messrs. Cammell Laird and Co., Limited, described in our last volume, was fitted with the first marine oil engine of the "Cammellaird-Fullagar" type, designed to develop about 500 brake horse power. In the course of exhaustive trials of both the hull and the machinery, the vessel proved very satisfactory and was sold to Messrs. T. and J. Brocklebank, Limited, Liverpool. Since then she has done nearly 10,000 miles in constant service, during which the engine has proved most satisfactory, giving practically no trouble and developing more horse-power than had been anticipated. The engine being more powerful than necessary for a coasting vessel of the size of the Fullagar, Messrs. Brocklebank have placed an order with Messrs. Cammell Laird for a similar engine in all respects; when this is completed the two units—the one at present in the Fullagar and the new one—will be installed in a twin-screw vessel of about 4,000 tons now under construction. The Fullagar engine will be replaced by machinery of much less power which will meet all the requirements of the coasting trade.

Tar-Condensation of Coke-Oven Gas.—During the discussion of Sir Arthur Duckham's paper on "Coal as a Future Source of Oil Supply," read before the Institution of Petroleum Technologists last week, and then mentioned by us, Dr. R. Lessing said that tar had not adequately been studied. So far as dyes came in question, tar investigation had certainly not been neglected; but the great bulk of the tar was still treated and distilled in the crude way of decades ago. The same question came up at the Naturforscher Versammlung, meeting in September last at Nauheim, in connection with a paper by Dr. Raschig, of Ludwigshafen, on the Walther-Feld process. Feld submits the hot coke-oven gases to a fractionated condensation, which deposits all the pitch (making up, perhaps, half of the tar mass) but does not so effectively condense the heavy oils which may pass into the ammonia liquor, if the temperature is allowed to exceed 70 deg. C. The other difficulty with the Feld process is the binding of both the ammonia and the sulphuretted hydrogen in the gases by a solution of ammonium polythionate. In the reaction the polythionate splits up into sulphur, which is deposited, and thiosulphate; the latter is subsequently re-converted into polythionate by sulphur dioxide. But the reactions do not proceed as desired, unless the solutions are concentrated, and the presence of much carbon dioxide is also a disturbing factor. Coke-ovens, Raschig remarked, can not be controlled like chemical factories.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in Italics.

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Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

146,697. Boulton and Paul, Limited, Norwich, and J. D. North, Burgh Apton. Metal Spars. (6 *Figs.*) June 5, 1919.—The invention relates to the construction of sheet metal spars for the wings of aircraft. In carrying out the invention, the spar is composed of similar girder structures, extending parallel to each other and spaced apart, having upper and lower booms of channel section, and in which the flanges of the said upper and lower booms face each other; the novel feature consists in the said booms, as also a complete girder structure composed therefrom, being connected or braced together by means of bracing members composed of strips of sheet metal rolled into a curved channel formation, the flanges being returned in curved form outwardly from each other and having the free edges of the section of the bracing lying in a plane which passes approximately through the centre of gravity of the said section, the said bracing members being connected to the flanges of the booms and to each other by rivets. The upper boom 1 and lower boom 2 of the girder structure each consists of a strip 3 of high tensile steel rolled to a channel section with the edges 4 of the side flanges 5 of the channel section strip 3 turned outwards in order to stiffen the free lips of the channel. The flanges 5 of the

Fig. 1.

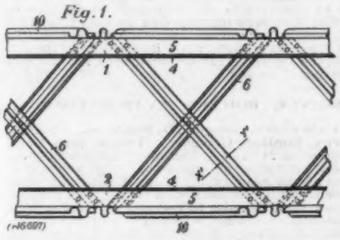


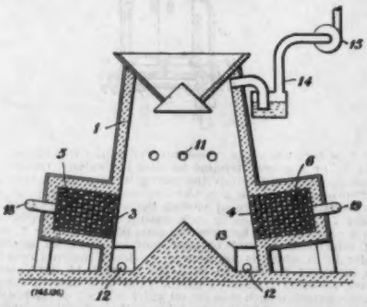
Fig. 2.

Fig. 3.

upper channel boom 1 are turned downwards, and the flanges 5 of the lower channel boom 2 are turned upwards. These booms 1 and 2 are connected at the proper distance apart by web bracing members 6 extending between the upper and lower booms 1 and 2 of each girder. These bracing members 6 are each composed of a strip of metal roller into a double "S" section, that is, the section may present the form of an inverted curved channel, the flanges 7 being returned in curved form outwardly from each other, the free edges 8 of the section of the bracing lying in a plane which passes approximately through the centre of gravity of the section, that is, the centroid and the free edges 8 lie in the same plane. The girder structure is built up in elevation by placing a number of such bracing members 6 back to back and riveting the ends of the side channels of each member 6 to the interior of the downwardly and upwardly extending side flanges 5 of the booms 1 and 2. Two parallel girder structures as above described are braced together by flange-bracing members 10 extending between the two upper surfaces and the two lower surfaces of the booms 1 and 2, and fixed thereto, and these flange-bracing members 10 are constructed of a section analogous to that described with reference to the web bracing members 6. In a built-up wing, the ribs, which may be constructed of similar section metal, where they cross the spars, will act as bracing members 10. (*Accepted July* 21, 1920.)

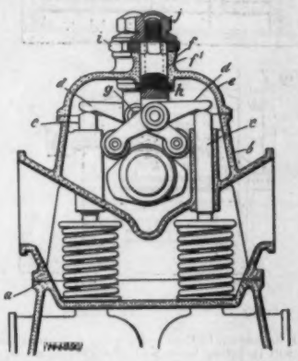
GAS ENGINES, PRODUCERS, HOLDERS, &c.

145,136. J. Harger, Liverpool. Gas Producer. (2 *Figs.*) March 22, 1919.—The invention relates to gas producers, and consists in a gas producer having two opposite side inlet and outlet openings below the level of the fuel and adapted to be operated so that the gases alternate in their general horizontal direction through the producer, and so that steam is followed by air in each case. 1 is a producer which is provided with side



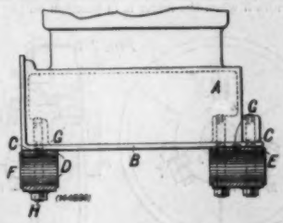
ports 3 and 4, serving alternately as inlets and outlets. These are connected to regenerators 5 and 6, and through valves to a recuperator. The fuel is introduced through the charging hole, poked down through the poke holes 11, and the mineral content removed in liquid form through the passages 12. Doors 13 are provided for removal of any clinker. If it is desired to distil coal on the bottomless retort principle, a limited quantity of gas is drawn off through the hydraulic main 14 by the exhauster 15. The producer proper may be operated so as to yield either producer gas or water gas as desired. In the former case air and steam or air and carbon dioxide are blown through the recuperator pipe 18, regenerator 5 and inlet 3, and producer gas is removed by the port 4, regenerator 6, pipe 19 and recuperator. The direction of flow is then reversed after a suitable period. In order to make water gas, the following sequence occurs. Steam is blown through the inlet and removed through the outlet until the fuel near the end is sufficiently cooled down. At this point, although the regenerators are of little use for heating up steam, they still contain much heat which can usefully be employed for heating up air. The air is therefore blown through the steam inlet for the blow period. In the next "run" period, steam is blown in the opposite direction followed by air also in the opposite direction. (*Sealed.*)

144,990. W. Hall, London, and R. Wellesley Goodmayes. Valve Mechanism. (2 *Figs.*) April 3, 1919.—The invention relates to valve operating mechanism of internal-combustion engines of the kind wherein the valves are operated by means of rockers interposed between the valve tappets and a cam, and pivotally mounted in bearing supports adjustably attached to a fixed part of the engine. According to the invention, each adjustable bearing support is made integral with, or is attached to a male member in screw-threaded engagement with two rotatable female members each of which is positively limited, one in one direction and the other in the reverse direction, in its axial movement relative to the fixed parts of the engine. *a* is the head of the cylinder against which the lower end of the valve springs abut, *b* is the casing containing the camshaft and tappets



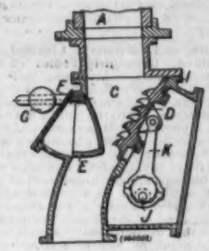
which is detachably secured to the head of the cylinder *a*, *c* are the tappets actuated by rockers *d*. *e* is the cover of the casing *b*, which is provided with vertically-projecting bosses *f* within which are carried internally-screwed sleeves *f*1. Each of the rockers *d* is mounted upon a fulcrum pin *g*, carried in a forked support *h* which has a shank suitably screwed to engage within a sleeve *f*1. The sleeve *f*1 is formed with a hexagon at its upper end which passes within a collar *i* also having a number of flats on its edge to receive a spanner. The screwed shank of the rocker support *h* extends beyond the edge of the sleeve *f*1, where it terminates in a second screw thread for the reception of a lock-nut *j*. The outer faces of the forked support *h* are shaped to slide in guide lugs depending from the cover *e*. These guides perform the dual function of retaining the fulcrum pin *g* and preventing the rotation of the rocker support *h* during its vertical adjusting motion. (*Accepted June* 30, 1920.)

144,880. G. A. Phillips, Coventry. Crank-Case. (2 *Figs.*) June 24, 1919.—The invention relates to crank-cases for fluid pressure engines. According to the invention, the bearing halves are all carried by upper and lower blocks, which are bored before fitting and are bolted up to flat faces in the same plane as the jointing face, and each upper block is located by a single central dowel. The upper half A of the crank-case is of normal construction, except that the jointing face B and the face C are in one plane and are machined flat, as by milling. To the faces C are bolted pairs of blocks D and E which carry the bearing bushes F, and which are machined separately from



the crank-case in accurate jigs to ensure correct depth, accurate bore for bearings F, &c., so that they require no machining when in place on the crank-case. To locate each upper block D or E accurately in place, there is a single central dowel G between the block and the crank-case, thus allowing each bearing to be self-aligning and ensuring accurate fitting. The main bearing bolts H have a clearance in both pairs of blocks D and E to permit of this self-alignment. Thus the crank-case does not require boring at all, and all flat machining is in a single plane and the bearing blocks can be supplied and fitted already machined, and the crank-case does not have to go on to a boring machine. (*Sealed.*)

144,952. J. Mitchell, Nelson. Coke-Extracting Apparatus. (1 *Fig.*) November 5, 1919.—The invention relates to apparatus for mechanically withdrawing and discharging packed material from a retort in as large pieces as possible and at the same time preventing a "run" or "hang up" in the mouth of the container. In carrying out the invention, one or more reciprocating claw plates having motion in one or more planes is, or are, fixed to the discharge mouth of the retort, one of the reciprocating movements being in a plane making an acute angle with the axis of the retort and (when used) another movement being at right angles to the axis of the retort. A represents the retort; C is the hopper joined to the retort through a connecting box or discharge piece; D shows one "claw-plate" sliding on the inclined surface of the hopper body I. The "claw-plate" D is reciprocated by a rotating shaft J having an eccentric with connecting rod K connected at one end to the "claw-plate." Opposite to the "claw-plate" on the other side of the hopper C is a swinging door E depending from and fixed to a horizontal shaft F. A lever carrying a counterweight as G is



fixed on the shaft F, and causes the door E to approach the "claw-plate" D at their lower ends with any degree of pressure requisite to break off the descending coke by pressing it towards the "claw-plate" and to prevent a "run" of the material. The door E is accommodated in a suitable recess formed in the hopper casting C. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

146,641. Sir C. A. Parsons, Newcastle-on-Tyne, S. S. Cook, Newcastle-on-Tyne, and L. M. Douglas, Newcastle-on-Tyne. Gear Trains. (13 *Figs.*) April 14, 1919.—The present invention relates to gear trains, and especially to double-reduction gear trains of the double-helical type, in which a primary pinion drives two primary gear wheels mounted on intermediate shafts carrying secondary pinions which engage with the main gear wheel. The invention consists in a double helical gear train in which a primary pinion drives two primary wheels mounted on intermediate shafts carrying secondary pinions which engage with a main gear wheel, both of the separate helices

Fig. 1.

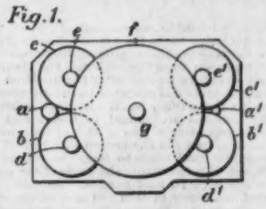


Fig 2.

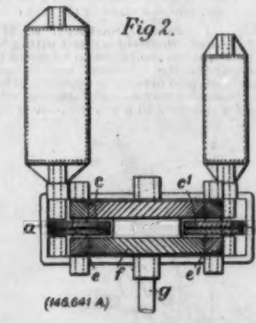


Fig. 3.

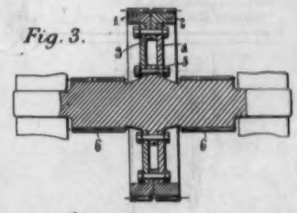


Fig. 5.

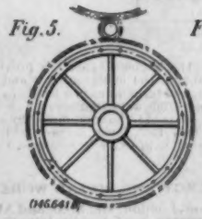
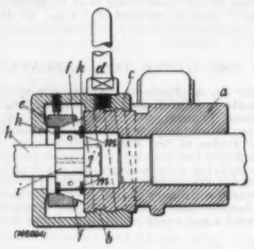


Fig. 4.

of one of the two toothed elements on one of the intermediate shafts being provided with permanent or constructional means for circumferential or axial adjustment. Two primary pinions *a*, *a*1, are each arranged to drive two primary gear wheels *b*, *c*, *b*1, *c*1, mounted on intermediate shafts, on which are also mounted secondary pinions *d*, *e*, *d*1, *e*1, which engage with the secondary gear wheel *f* on the driven shaft *g*. The primary gear wheel comprises two adjustable helices 1, 2, bolted to webs 3, 4, which are themselves bolted to a flange 5 on the intermediate shaft, on which are cut the secondary pinion teeth 6, 6. In this case the gear train is assembled by mounting all the members in

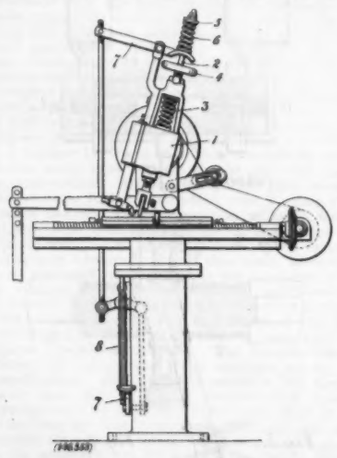
position and locking the first or last member of the train. Torque is then applied in the appropriate direction to the other members of the train, including the two adjustable helices. The helices are constrained longitudinally but have circumferential freedom, and they are each moved until each set of teeth is in proper contact when they are bolted to the webs, and dowel pins or other registering means fitted to retain them permanently in this position. (*Sealed.*)

146,684. Smith and Coventry, Limited, Salford, and I. H. Wright, Salford. Broaching Tools. (2 *Figs.*) May 21, 1919.—The invention relates to broaching tools of the type in which a shank or toolholder is pulled through its operative stroke with respect to the work-piece. The invention comprises means for connecting the broach shank with the pulling head of the machine. The pulling head *a* is provided with a coarse and shallow thread *b* on to which screws a socket member *c* having an operating lever *d* for imparting the required rotary movements thereto. The said socket *c* contains a ring *e* having a conical interior surface adapted to coact with the correspondingly coned ends of collets *f*, which are normally held together in an expanded annular form by means of a spring inserted in slots in the adjacent faces of the collets. The pulling head of the broach shank has a recess *i* to receive the collets so that the latter may transmit the pull from the pulling head to the shank by way of a shoulder *j* adjacent its extremity. When the lever *d* is operated to unscrew the socket *c* the movement of the latter withdraws the internally-coned



surface of the ring *e* from the correspondingly-coned end of the collets *f* so that the latter are in the expanded form given by the springs. With the collets thus expanded the broach shank *h* can be freely withdrawn from the socket. For the connection of the shank and socket for service, after the insertion of the one within the other, the lever *d* is operated in the direction to screw the socket *c* on to the pulling head. By such movement the respective coned surfaces are caused to co-act and force the collets, against the expansive action of the springs, into engagement with the necked part *i* of the broach shank *h*. The pulling action of the machine itself tends to close the collets and keep same in engagement with the shank, the angle of the cones giving such automatic closing. To hold together the collet sections a ring *k* is provided in a recess in each end face of the collets and the said rings are connected together by long pins *m* which pass through the gaps between the collets and have their heads riveted over. The collet closing ring *e* is maintained in a central position by means of the screwed pins *m* secured in the part *c*. (*Sealed.*)

146,553. R. J. L. James, Sheffield, E. H. James, Sheffield, and J. James, Sheffield. File-Cutting Machines. (1 *Fig.*) February 6, 1919.—The invention relates to file-cutting machines. According to the invention, one or more blow-absorbing springs are adapted to lie on an extension of the hammer block and to be brought to bear on said extension with more or less pressure, when it is desired to lessen the blow of the hammer



to any required extent. The hammer block 1 is provided with a stem 2, that passes through the main spring 3 and its compression adjusting screw 4, and terminates in a head 5. Between this head 5 and the compression adjusting screw 4 is disposed a blow-absorbing spring 6 adapted to be compressed by a suitable foot-operated lever 7. This foot lever is preferably spring-controlled by a coiled spring 8, in order to minimise the shock. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

145,284. J. S. Atkinson, London, and Stein and Atkinson, Limited, London. Furnaces. (3 *Figs.*) July 17, 1919.—The invention relates to furnaces for the heat treatment of metallic bodies, of the kind in which the bed comprises a plurality of portions, some of which are fixed and some of which are movable and counterbalanced, and in which the body to be subjected to heat treatment is caused to pass through the furnace in a step by step manner, by the action of the movable portion or portions thereon. In a furnace for the heat treatment of metallic or other bodies of the kind referred to, and in accordance with the invention, the novel feature consists in combining with the bed constituted of fixed and movable portions, means to cause the movable portions to move in a circular path in relation to the fixed portions and self-acting means for counterbalancing the weight of the movable portions and movable independently of one another. 1 is the heating chamber of the furnace, the bed of which comprises a fixed and central portion 2 and two movable and outer portions 3. 4, 5 are shafts extending transversely of, and below, the bed. The shaft 4 is driven by an electric motor 7 through gearing 8. The shafts 4 and 5 are cranked, and each has a central cranked portion 9 situated below the fixed portions 2 of the bed and other cranked portions 10 situated below the movable portions 3 of the bed. The cranked portions 9 of the shafts 4, 5 are coupled together by a connecting rod 11. The movable portions 3 of the bed have, on their undersides, downwardly extending brackets 12, which are situated above the cranked portions 10 of the shafts 4, 5, and to which they are coupled. The arrangement is such that when the motor 7 is started up and is running the two shafts 4, 5 are rotated in unison and the movable portions 3 of the bed are caused to move in a

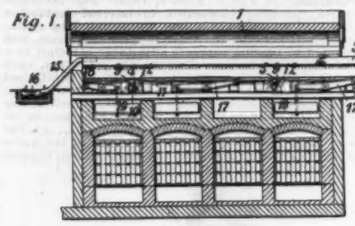


Fig. 1.

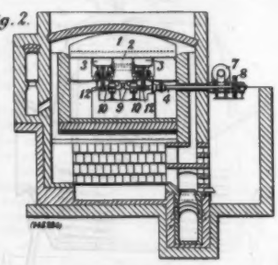


Fig. 2.

circular path in relation to the fixed portion 2. An object placed in the bed will therefore be caused to travel in a step-by-step manner through the heating chamber 1. The objects to be subjected to heat treatment are placed on feeding rolls 14. The objects are removed from the feeding rolls 14 by the movable portions 3, the lengths of which are such that they extend between adjacent rolls 14. The treated objects are delivered from the rear end of the heating chamber 1 on to inclined ways 15 down which they slide on to discharging rolls 16. 17, 17 are levers of the first order: these are pivotally mounted on brackets below the movable portions 3 of the bed, and are movable independently of one another. Each lever has, at one end, a roller 18 and, at the other end, a weight 19. The weights 19 cause the rollers 18 to bear against the undersides of the movable portions 3 of the bed, and are further such that the weights 19 below each movable portion counterbalance the weight thereof. (*Sealed.*)

MOTOR ROAD VEHICLES.

144,985. C. E. Newton, Lincoln. Detachable Wheel. (7 *Figs.*) February 11, 1920.—The invention relates to detachable wheels for road vehicles. According to the invention, the wheel is locked to the permanent wheel hub by engaging levers pivotally attached to the wheel hub and adapted to engage a flange carried by said hub and to be retained in the locking position by the conical exterior surface of the wheel cap engaging under the free ends of said levers. The axle 1 is provided with a permanent hub 2 consisting of a sleeve mounted on the axle end, and in driving connection therewith. The hub 2 is provided with a flange in one with the hub or rigidly attached thereto. The flange 4 is provided on its inner side with recesses adapted to receive correspondingly-shaped projections at the inner end of the wheel hub 3 when the latter is in position on the permanent

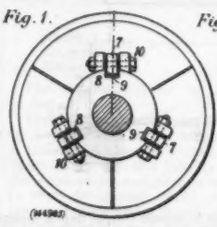


Fig. 1.

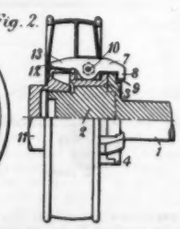


Fig. 2.

hub 2. The wheel hub is provided with a series of locking levers 7 provided with hooked ends 8 adapted to engage in recesses 9 formed in the outer side of the flange 4. These locking levers 7 are pivoted at 10 to the wheel hub and provided with tail pieces 13 extending beyond the hub. A wheel cap 11 is screwed on to the end of the permanent hub 2. This wheel cap is provided with a conical exterior surface 12 to engage beneath the tail-piece 13 of the locking levers 7 and thus hold said levers in the locking position with the hooked ends 8 in engagement with recesses 9 on the flange 4 when the wheel hub is in position on the permanent hub of the axle. The drive is transmitted to the wheel through the flange 4 and projections on the wheel hub, while any lateral stress to which the wheel may be subjected is taken by the members 7 and the flange 4 of the hub 2, and are not transmitted to the wheel cap 11. (*Sealed.*)

145,155. W. Frost, London, and Harvey Frost and Co., Limited, London. Vulcaniser. (6 *Figs.*) March 25, 1919.—The invention relates to portable vulcanisers for tyre repairs. The vulcaniser comprises a steam chamber A, which is in communication with a steam-generating chamber A1. A^2 are tubes for the passage of the hot gases of combustion from a burner. The front portion of the steam chamber is made to overhang the steam-generating chamber so that a forwardly-projecting neck A^3 is provided having a surrounding circular flange A^4. The flange

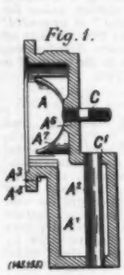


Fig. 1.

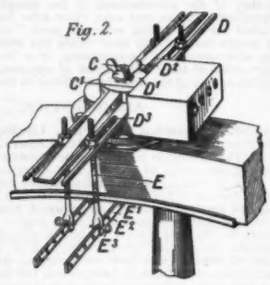
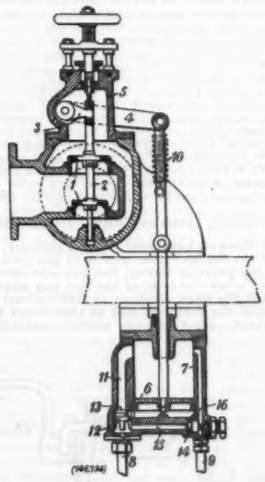


Fig. 2.

is provided with a series of notches to receive bolts, and the front wall of the steam chamber is provided by a moulding plate having notches corresponding to the notches on the flange. The front face of the moulding plate is shaped to correspond to the particular tyre and to the particular part of that tyre with which it is intended to be used. The back of the plate is roughened at the edges to receive packing to make a joint with the flange A^4. The interior of the steam chamber A is strengthened by webs A^7 radiating from a central boss A^6, and in this central boss is secured a screw-threaded stud C. The back of the steam chamber is made flat, and it is set in from the back of the steam generating chamber, so that a square shoulder C^1 is provided. To secure the vulcaniser in place for effecting a tyre repair, a clamp is employed comprising an outer bridge-piece D, which is webbed along the centre to stiffen it and is provided with a central boss D^1 to receive the stud C. The bridge-piece is fixed to the vulcaniser by a wing-nut D^2 which is screwed on to the end of the stud C, and the side of the bridge-piece lies against the shoulder C^1. The ends of the bridge-piece are slotted at D^5, two slots being provided at each end which slots receive bolts E from co-operating bridging rods E^1. The rods are provided with a series of perforations E^2 and the bolts E are bifurcated at their ends and receive pins E^3, which can be inserted in any one of the holes E^2. The vulcaniser is clamped in position by the bridge-piece D and bridging rods E^1 connected to the bridge-piece by the bolts E, and the length of these bolts together with the slots D^5 and the holes E^2 in the bridging rods allow of considerable adjustment for different-sized tyres and makes of rim. By screwing up the nuts on the bolts E, the vulcaniser can be forced upon the tyre with considerable pressure. (*Sealed.*)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

146,754 D Cockburn, Glasgow, D. MacNicoll, Glasgow, and Cockburns, Limited, Glasgow. Engine Stop Gear. (1 *Fig.*) September 24, 1919.—The invention relates to an engine stop gear, including an emergency valve which automatically shuts off the steam supply to the engine in the event of failure of the forced lubrication system or drop of oil pressure, which emergency valve can also be operated by hand or by a governor. The emergency valve is formed as a balanced valve, in the particular instance as a double-beat valve 1, carried by a spindle 2 engaged by a lever arm 3 housed within the valve casing 5 and rigid with a lever arm 4 located externally of the casing 5 and operatively connected to a piston 6 movable in a cylinder 7, of which one end has a pipe connection 8 to the forced lubrication system or source of supply, and the other end has an overflow connection 9. Normally, the pressure of the liquid acting on the under face of the piston 6 maintains the levers 3, 4, and thereby the valve spindle 2 in such position that the



valve 1 is held open, the pressure overcoming the action of a spring 10, or a weight, tending to close the valve. On drop of pressure or failure of supply the spring 10 rocks the levers 3, 4, and displaces the spindle 2 in the direction to close the valve 1. To accelerate the action of closing the valve and prevent the cylinder 7 from functioning as a dash-pot there is provided a by-pass connection 11 between the ends of the cylinder 7, there being interposed in said by-pass connection 11 an auxiliary cylinder 12 in which is movable an auxiliary piston 13 serving when in raised position to close the by-pass 11, said second cylinder 12 being connected to the tank or source of supply. The arrangement is such that the oil which is to act on the piston 6 enters the cylinder 12 by the pipe 8 before it reaches the cylinder 7 and thus first closes the by-pass. Between the cylinder 12 and the overflow connection 9 is a passage 15, at the end of which, remote from the cylinder 12, is fitted a spring-loaded valve 14 controlling the opening 16 to the underside of the piston 6. As will be seen, on drop of pressure or failure of supply of oil the piston 6 will in any event fall. Also the auxiliary piston 13 falls and opens the by-pass connection so that the fall of the piston 6 is unimpeded. (*Sealed.*)